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An Impact Analysis of Small-Scale Fisheries Community-Based Fisheries Management (CBFM) in Asia: A Meta-Analysis

Di Yang, PhD

University of Connecticut, [2017]

ABSTRACT

The contribution of small-scale fisheries is significant regarding food security and employment, especially in the developing countries. However, with the persistent overfishing and unstainable exploitation, the performance of small-scale fisheries was severely devastated, not only due to its weak governance but of poor management, perverse subsidies, destructive fishing practices, and unrestricted access.

Community-based fisheries management (CBFM) is a process by which the people themselves are given the opportunity as well as the responsibility to manage their resources, define their needs, goals, and to make decisions that have an impact upon their well-beings. Due to its social and economic benefits of efficiency, equity and sustainability, it is widely employed in the developing countries in Asia.

This research focused on the impact analysis of CBFM on the sustainable management of fisheries resources and fisher's livelihood in Cambodia, Bangladesh and Philippines by applying meta-analysis to quantify the magnitude of intervention and analyze the heterogeneity of the effects in each country. By integration of difference-in-difference in the construction of effect size, more accurate estimate of effect sizes was derived. The results show a consistent positive effect on management indicators in all three countries, which justified that CBFM was an effective and sustainable approach to organizing and

managing fishing activities and fishing community. The mix results in the effect size of fish catch indicated that CBFM was better effective with the implementation of stock recovery programs.

An Impact Analysis of Small-Scale Fisheries Community-Based Fisheries Management (CBFM) in Asia: A Meta-Analysis

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B.S. Beijing Normal University, [2008]

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APPROVAL PAGE

Doctor of Philosophy Dissertation

An Impact Analysis of Small-Scale Fisheries Community-Based Fisheries Management (CBFM)

in Asia: A Meta-Analysis

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[2017]

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INTRODUCTION

1.1 Importance of Capture Fisheries

Fishing has been a major source of food as well as employment and economic benefits to people who engaged in these activities since ancient times. With increased knowledge and the dynamic development of fisheries, it was realized that living aquatic resources, although renewable, are not infinite and required to be properly managed, if their contribution to the nutritional, economic and social well-being of the growing world's population was to be sustained. Over the last half century, huge changes have taken place in the fishery (Béné, C., Macfadyen, G., Allison, E.H., 2007). The industrialization of the fisheries and the significant increasing international demand for fish has led to a massive increase of global fishing activity and brought ever-increasing catch rates since the 1950s. However, the increasing density of human activity causes serious pressure on the marine biodiversity. An estimation of the global state of fish stocks indicated an alarming result that the combined proportion of overexploited, depleted, and recovering stocks is 58 percent (Froese, R., Zeller, D., Kleisner, K., Pauly, D., 2013), compared to the highly-underestimated 32 percent reported by the FAO in 2010.

The coastal waters of Southeast Asia are among the most productive and biologically diverse in the world. Consequently, they are critical both for global fish production takes place in Asia, including 34 percent of the world's exports of fish and employing a staggering 87 percent of all fisheries and aquaculture workers (Sugiyama, S., Staples, D., Funge-Smith, S., 2004). The Association of Southeast Asian Nations (ASEAN), which consist of Indonesia, Malaysia, the Philippines, Singapore, Thailand, Brunei, Vietnam, Laos, Myanmar, and Cambodia, contributes to a quarter of global fish production, 21 million tons of fish products annually (Salayo, N., Garces, L., Pido, M., Viswanathan, K., Pomeroy, R., Ahmed, M., Siason, I., Seng, K., Masae, A., 2008).

Not only as an inevitable contributor, but Southeast Asia also relies more heavily on fish as a primary source of dietary protein and income generation than any other country in the world. The proper evaluation of the contribution of fisheries to food security should be interpreted from both dimensions of unit and scale. For calorie that required for human consumption on average, according to the FAO, less than 1 percent of the daily world gross consumption of food products (33,000 giga calories per day in 2003) originates from aquatic products, with 88 percent deriving from plants and 11 percent from land-based animal production (Paillard, S., Treyer, S., Dorin, B., 2011). The contribution of fisheries to food security seems by no means significant in this dimension. However, regarding protein consumption, the picture changes a lot. In 2007, fish accounted for 15.7 percent of the global population's intake of animal protein, and 6.1 percent of all protein consumed (Allison, E.H., Béné, C., Andrew, N.L., 2011). Put these percentages into the perspective; fish provides more than 1.5 billion people with almost 20 percent of their average per capita intake of animal protein, and 3 billion people with 15 percent of such amount of protein (FAO, 2010). It is estimated that between 15 and 20 percent of all animal proteins come from aquatic animals (FAO, 2010). Fish is critical nutritious and serves as a unique supplement in diets for the insufficiency of essential vitamins and minerals. With the well-recognized and acknowledged facts by the of Nutritionist, even in small quantities, fish can have a significant positive impact in improving the quality of dietary protein by complementing the essential amino acids that are often present in low quantities in other diets. The increasing research shows that fish is far more than just an alternative source of animal protein. Fish oils in fatty fish are the richest source of a type of fat that is vital to normal brain development in unborn babies and infants. Without adequate amounts of these fatty acids, normal brain development does not take place properly. In particularly, closely spaced pregnancies, often seen in developing countries, can lead to the depletion of the mother's supply of essential fatty acids, leaving younger siblings deprived of this vital nutrient at a crucial stage of their growth. This makes fatty fish such as tuna, mackerel, and sardine, all of which are widespread in developing countries, a particularly healthy choice for the diet of pregnant and lactating women. The latest available global data on fish supply is for 2007 (FAO, 2011) which indicates that in the least developed countries, per capita fish supply (trade is included) is 9.5 kg/person/year, while in industrialized countries, it is more than three times higher, 28.7 kg/person/year. Africa has an average per capita supply of 8.5 kg/person/year, while Oceania has 25.2. In general, people in developing countries are much more dependent on fish as part of their daily diets than those living in the developed world. Figures for 1995 show that while fish provide slightly over 7 percent of animal protein in North and Central America and more than 9 percent in Europe, in Africa they provide over 17 percent, in Asia over 26 percent, and in the low-income with food deficit countries (LIFDCs) including China they provide nearly 22 percent. In 1990, around 845 million people around the world were hungry. Between 2006 and 2009 the incidence of hunger rose from 873 million to just over 1 billion people, falling again slightly in 2010 to 925 million, along with signs of global economic recovery (Fan, S., 2010; Foresight, 2011). In the wake of this economic volatility, the question of how to produce and distribute enough food for a projected global population of 9 billion people in 2050 has become a central concern of development policy (World Bank, 2013). Demand for fish is expected to increase substantially, at least in line with other animal-based foods, and that further escalate the important role of fisheries in providing livelihoods, trade, and food security to all the people who lives in the region, particularly in South and South-east Asia.

The fisheries sector also has an inevitable contribution to poverty alleviation and employment in several different ways. Fisheries contribute to poverty reduction through wealth creation at the household level, as a rural development engine at the community level and by generating economic growth at the national level, including contributions to GDP, government tax income, and foreign exchange earnings. Also, fishery sector can help people stay out of or not fall further into poverty by providing a minimum standard of living and a safety - net function (Béné, C., Macfadyen, G., Allison, E.H., 2007). There is more evidence indicating that, especially in developing countries. Although fishing activities may not generate high incomes for the households involved, they might help them sustain their livelihoods and stop them from falling deeper into the poverty. If access to fishing grounds is relatively easy, but access to other capitals, such as financial, physical or other production factors is limited, poor people in the fishing community are more likely to turn to the common fishery resources to sustain their livelihoods. Moreover, in a situation where the normal means of income generation have been disrupted, for example, the household head has lost his or her job, or in a more widespread disaster situation, fishing may provide a safety - net function also to vulnerable population groups who were not previously poor. This role is particularly important and unique for small - scale fisheries in developing countries since they provide a "welfare" system that may not be available from other institutions, although less attractive from an economic perspective.

While small - scale fisheries contribute to poverty reduction by providing employment to many established fishers and fish workers, it probably plays an even more important role in poverty prevention. Over half a billion people are fully or partly involved in fisheries, aquaculture and related industries, 95 percent of them in developing countries. For each people employed in capture fisheries and aquaculture production, about three jobs are produced in secondary activities, including post-harvest, resulting in an estimated total of more than 180 million jobs in the fishery sector. Aquaculture and related processing industries provide new economic opportunities, particularly for female employment. On average, if each jobholder has three dependents or family members, the primary and secondary sectors support the livelihoods of a total of 540 million people, or 8 percent of the world population (FAO, 2011).

1.2 Small-scale fishery

Small-scale fisheries operate from shore or with small vessels (Allison, E.H., Ellis, F., 2001), and involve simple fishing gears with low capital investment (FAO, 2014). With nearly 90% of world's 120 million full-time and part-time fishers are involved to derive their livelihood, and the significant contribution to 70% of world catch, small-scale fisheries is by no means small in terms of population and contribution and can hardly be overestimated in terms of source of nutrition, employment, and income (Mills, D.J., Westlund, L., De Greef, G., Kelleher, K., 2011). As a giant but full of the variant sector, the Food and Agriculture Organization (FAO) tried to combine all the characteristic dimensions of this sector and summarized the small-scale fisheries as:

“Traditional fisheries involving fishing households (as opposed to commercial companies), using the relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, the definition varies between countries, e.g. from a one-man canoe in poor developing countries, to more than 20-m. trawlers, seiners, or long- liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. They are sometimes referred to as small-scale fisheries”. (Béné, C., Macfadyen, G., Allison, E.H., 2007)

Setting aside augments in definition, the date of the estimates and the criteria for inclusion, there are approximately 14 and 20 million (Pomeroy, R.S., Williams, M.J., 1994) people who participate in small-scale fisheries, and this number bumped up to 40 million in 2003 (Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S., Ahmed, M., 2003). If one includes fisheries-associated activities and livelihoods, which indicate both pre-harvest (e.g. gear construction, maintenance, port facilities support, ice supply) and post-harvest (e.g. processing, marketing, and transportation) processes, as well as children and the elderly in fishing households, nearly 300 million people, may depend on small-scale fisheries and related activities (Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S., Ahmed, M., 2003). These fisheries make crucial but always been poorly quantified, contributions to national and regional economies, and to the food security and development of many millions of people. To date, there are no reliable global estimates of the population who dependent on small-scale fisheries, not to mention the reliable assessments of their role in national or regional economies. Nevertheless, a broadly recognized fact is that the numbers are surprisingly huge and its contributions have been highly underestimated, especially to the human nutrition, regional development, and poverty alleviation. (Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R., 2001; Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S., Ahmed, M., 2003; Chuenpagdee, R., Preikshot, D., Liguori, L., Pauly, D, 2006).

With engaging the vast majority of the world's fishers, small-scale fisheries are struggling to keep pace with coastal populations, and stocks are declining to levels that severely threaten reproductive capacity. However, they play an inevitable role as a source of livelihoods, food security and income for millions of people around the world in both developed and developing countries (Allison, E.H., Ellis, F., 2001; Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R., 2001). Many characteristics inherent in the small-scale fisheries make them vulnerable to threats and shocks which are not only from inside the fisheries, such as overfishing and excess capacity, but also from outside at a broader perspective, such as economic shocks, and even climate change. Since small-scale fisheries have its uniqueness regarding contribution to economic development and more importantly, to food security and social safety net function at the same time, it is hard to balance values and measures on issues of equity, and social justice.

Small-scale fisheries abound in developing countries throughout the tropics as many of the tropical marine fishes and invertebrates are in waters accessible by shallow fishing gears, breath-hold divers, and intertidal gleaners. They are tied inextricably to the resilience and fate of coastal and reef ecosystems (Hawkins, J.P., Roberts, C.M., 2004; Batista, V.S., Fabre, N.N, Malhado, A.C.M., Ladle, R.J., 2014), which are simultaneously impacted by global and local stressors (Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K., Knowlton, N, Eakin, C.M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R.H., Dubi, A., Hatziolos, M.E., 2007). In spite of the important role that small-scale fisheries play in national and local economies (Mills, D.J., Westlund, L., De Greef, G., Kelleher, K., 2011), this sector, as compared to other sectors of the world food economy, is far less sufficient investigated and regulated, inadequately funded, marginalized and often neglected by all levels of government (Virdin, J., Gardiner, P., Santen, G., 2004). Fisheries policies often choose to avoid the ‘hard choices’ that need to be made to resolve these conflicts (Bailey, C., Jentoft, S., 1990). Thus, the provision of food and livelihoods to low-income fishers into the future will be unrealistic without radical changes to fisheries policy. Yet on the flip side, considering the fundamental and potential contribution to both reducing poverty and improving food security (Béné, C., Hersoug, B., Allison, E.H., 2010), if small-scale fisheries have effectively managed, the continuing collapse of aquatic and marine ecosystems and the loss of associated biodiversity occurring throughout the world’s oceans and aquatic environment can be avoid (Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R., 2001).

1.3. Problems

The industrialization of the fisheries and the significant increasing international demand for fish has led to a massive increase of global fishing activity. The fishing effort continues to soar even though the world catch has stabilized, if not declined slightly, since the mid-1990s (FAO, 2011).

Moreover, the increasing density of human activity causes serious pressure on the marine biodiversity. There is growing concern worldwide about the impacts of overfishing, the use of destructive fishing gear, pollution and climate change on the sustainability of fisheries, social and economic conditions of fishers as well as the fishing community. Although the problem of overcapacity is well realized and relatively less complicated to analyze, as most pervasive forces negatively affecting the fisheries, overcapacity remains one of the most intractable problems in fisheries management. To date, 90 percent of the world's fisheries are either fully exploited, overexploited or have collapsed already (Pomeroy, R.S., Andrew, N., 2011).

1.3.1 Overfishing

Overfishing occurs when the number of mature fish is reduced to a certain level where reproduction and recruitment are unable to compensate the losses, then fish stock will continue to decrease and disappear as a result. Over 85 percent of the world's fisheries have been harvested to or even beyond their biological limits and are badly in need of effective management to have them restored (FAO, 2010; Worm, B, Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., 2006). A consistent shrink was represented in the fish stock during 1974 to 2004, which proportion of overexploited and depleted stock increased from 10 percent to over 30 percent during 30 years. At the end of 2008, more than half of the stocks in the world were estimated to be fully exploited with no room for further production (FAO, 2010). Gathering as many fish as possible may seem like a profitable practice, but overfishing has serious adverse consequences.

The subsequent results not only affect the balance of life in the marine ecosystem but also, more profoundly, the social and economic well-being of the coastal communities, particularly the people who has high dependency on fish for their livelihoods. Billions of people rely on fish for protein, and fishing is the principal livelihood for millions of people around the world. For centuries, our seas and oceans have been considered as an endless generosity of food. However, overfishing led to the collapse of many fish stocks and a more grievous reality is that due to the specific targeting species for their significant commercial value, like the predators near the top of the food chain, such as Atlantic Bluefin tuna which have declined to the tipping point where their survival as a species is threatened already, irreversible damage has taken place to the entire marine food chain and a gradual impact on prey and predatory species will be expected subsequently. Other than overfishing quantitatively, fish are frequently captured before reaching their sexual maturity to increase the landing. Such impatient and short-sighted harvest behavior will highly weaken the capability of restocking. With increasing fishing efforts over the last 50 years as well as unsustainable fishing activities, many fish stocks are pushed to the edge of total collapse, which will eventually push the whole marine ecosystem to an imbalanced and problematic bio-composition.

1.3.2 Overcapacity

Fishing capacity is defined by FAO (2000) as 'the amount of fish (or fishing effort) that can be produced over a period by a vessel or a fleet if fully utilized and for a given resource condition.' To better understand the term ‘overcapacity,' the meaning of ‘excess capacity’ must be comprehended in advance, which shares some similarities with overcapacity. Excess capacity happens when boats operate for fewer days than expected due to lower prices, higher costs or weather condition. It exists when potential catch or effort is greater than actual catch or effort in a short period. Whereas overcapacity refers to a long-time concept that used to convey the situation that fishing capacity is greater than the optimal level in terms of catch, fleet, engine and mesh size, etc. In simple terms, overcapacity refers to the fact that there are 'too many fishers chasing too few fish' (Lalli, C.M., Parsons, T.R., 1993).

Garcia and Newton (1995) estimated that world fishing capacity would need to be reduced by 25 percent for revenues to cover operating costs and by 53 percent for revenues to cover total costs. A report published by the World Wildlife Fund (WWF, 1998) indicated that the world fleet was 2.5 times (150%) greater than world fish stocks could sustain. The problems of overcapacity have become a key issue in fisheries management and followed by many severe consequences, which including overinvestment in fishing boats and gear; too many fishers; reduced profit and decline in quality of life of fishers and their families; increasing conflict in the fishery, and political strife in the management process. In 1999, the FAO Committee on Fisheries adopted 'The International Plan of Action for the Management of Fishing Capacity', which calls for states to prepare and implement national plans to effectively manage fishing capacity, with priority to be given to managing capacity on fisheries where overfishing is known to exist (FAO, 2011).

1.3.3 Low Efficiency

One inevitable impact of overexploited fisheries resources on the small-scale fisherman is low efficiency in terms of production and profit. In an early research of Lamotrek Atoll (Alkire, W.H., 1965), an estimate of merely 4 kg harvest per fisher per trip in the Southwest

Pacific had been made. In addition, based on data presented in a research of Javanese coastal villages in the Philippines (Collier, W.L., Hadikoesworo, H., Saropie, S., 1979), the annual catch for practitioner of motorized bancas was approximately 2.6 Metric tons, while the practitioner of non-motorized bancas caught only 1.0 Metric ton on the average, in spite of making 20% more trips every year (Herrin, A.N., Fabello, C.E., Palma, L.C., 1978). Moreover, incompatibilities between fish farming and small-scale fisheries potentially exist, and conflicts are most common than synergies. In general, it has been observed that the productivity of the small-scale fisheries is strictly linked with the importance of the offshore semi-industrial fisheries. All the scientific studies dealing with the interactions between fisheries show that a decrease in the fishing effort of the large boats -particularly the trawlers- will result in a substantial increase of the small-scale vessels catch per unit effort. Multiplying by a low price at the market, the income that fishers make is by no means fair and enough, even for the sustainability of themselves and their family.

1.3.4 Population growth

Population pressure aggravates the circumstance of not only overcapacity and overfishing, but also adds more challenges to the local fishing communities as a result. Coastal areas in Southeast Asia are typically heavily populated with larger numbers of the poorer household being dependent on the fishery resources. The UN projects the highest population growth in Sub-Saharan Africa, where the population is projected to increase by 57.6 percent and the annual rate of 2.3 percent between 2010 and 2030. Given that the fish production is expected to grow by 23.6 percent during that period. The World Bank Group (WBG)

Agriculture Action Plan 2013–151 estimated the global population is expected to reach 9 billion by 2050. In contrast to this urgent need from the sea, however, world fish capture production remains stable, if not decline, since 1995 (World Bank, 2013). Although the hope might be sought in the sector of aquaculture as World Bank estimated that the global aquaculture projection maintains its steady rise from historical levels, reaching the point where it equals, if not exceed, global capture production by 2030 (FAO, 2014), relocating excessive labor and capital to the aquaculture sector involve not only regional administration reform, but also the transformation of entire livelihoods of people who used to fish for generations, let alone the issues of incomplete coverage of enforcement due to scatter geographic location and the level of acceptance and compliance with this transition.

1.3.5 Conflicts

The combination of population growth and multiple sources of fishing pressure is leading to a high level of conflict among different users over the remaining fish stocks (Pauly, D., Christensen, V., Sambilay, V.C., 1990). A complex, negative feedback cycle is generated in this tangled compound, whereby rapid population growth aggravated by fewer economic opportunities and access to land surges the number of people who are living in the coastal zone and highly dependent on fishery resources.

The growing fishing pressure results in both decline of stocks and increased resource competition, between all individual fishers and different scales of fishing operation, such as small-scale vs. industrial (Stobutzki, I., Miller, M., Brewer, D., 2001). Although many countries make inshore marine areas and inland waters for small-scale fisheries exclusively, there are other situations where both fisheries compete for the same fishery resources (Jacquet, J.L., Pauly, D., 2008). In fact, many of the species targeted by the small-scale fishermen are also exploited by the offshore fleets which apply an intensive fishing effort on the stocks. Thus, higher rates and probabilities of human conflict appear afterward over the remaining stocks. This unfavorable cycle leads to a pattern of self-reinforcing “fish wars” with deteriorating social and environmental consequences (Pomeroy, R.S., Parks, J., Pollnac, R., Campson, T., Genio, E., Marlessy, C., Holle, E., Pido, M., Nissapa, A., Boromthanarat, S., Thu Hue, N., 2007). Moreover, in some region where industrial fishing fleets take advantage of sonar system as well as advanced fishing gear to “vacuum” the region and left nothing behind for the small-scale fishers, whose gears and boats limit them to access and have a much higher dependence on fish for their food and livelihood. The fishers and their families who hang on the edge of sustainability will seek from the sea regardless and defense their food in the sea against any potential threat they might face. For example, small-scale fishers in Indian have lately been very vociferous in condemning shrimp trawlers whose fishing methods jeopardize fish stocks. Also, in the Philippines and Thailand, such competition is known to regularly lead to violence, and even fatalities (Siason, I.M., Ferrer, A.J., Monteclaro, H.M., 2005; Nissapa, A., Khemakorn, P., Masae, A., Siripech, A., 2005).

Such competition is not always passive in nature, as armed conflict and violence are increasingly being reported (Pomeroy, R.S., Parks, J., Pollnac, R., Campson, T., Genio, E., Marlessy, C., Holle, E., Pido, M., Nissapa, A., Boromthanarat, S., Thu Hue, N., 2007). The result of increasing competition is reduced income and food security, increased poverty, vulnerability and a lower overall standard of living and national welfare (Sugiyama, S., Staples, D., Funge-smith S., 2004). Therefore, this intensive situation makes fishers tend to employ more over-efficient fishing practices and even destructive technologies in the "rush" to catch what remains in the sea, thereby further depleting fishery populations. Decreasing fish stocks combined with increasing conflict are driving some people out of fishing, not in a favorable direction though. This is leading to increasing unemployment in many rural areas and adding an extra level of instability contributes to national levels of social unrest and political instability, resulting in acting as a powerful and destabilizing risk factor to regional and global security concerns. The imperative of immediately reconciling the compounding needs for improving the ecological sustainability of fisheries consumption while also improving food security and reducing overcapacity and resource conflicts have recently begun to be widely acknowledged (Morgan, D.G., Abdallah, S.B., Lasserre, P., 2007).

1.3.6 Illegal fishing

Illegal fishing is estimated as 30 percent of the world total fisheries landing. However, most of the studies on this issue have focused on industrial fisheries, leaving small-scale fisheries behind even though they contribute a much more to this portion (Agnew, D., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J.R., Pitcher, T.J., 2009). As for the number of values, illegal fishing leads to annual global monetary losses of up to $ 23.5 billion dollars, heavily undermining the far from efficient fisheries management, generating adverse effects on exploited fish populations and associated livelihood and food security services (FAO, 2005).

Many characteristics inherent in the small-scale fisheries facilitate a high level of illegal fishing in developing countries. These regions possess large numbers of small-scale fishers that live in geographically dispersed communities where alternative sources of employment are scarce (FAO, 2011). Governments in these regions have insufficient human and financial resource to deploying and monitoring in rule enforcement, so a very low-level of compliance with management rules is expected and is actually appeared, especially in the regions possess multispecies fisheries where various species are usually simultaneously harvested. Therefore, the high monetary value of some key commercial species become significant incentives to either catch restrictive species or catch over the limit or both (Pauly, D., 2006). The reckless practice of harvesting leaves irreversible impacts on many other species even they are not desirable (Gerrodette, T., Dayton, P.K., Macinko, S., Fogarty, M., 2002; Kura, Y., Revenga, C., Hoshino, E., Mock, G., 2004; Raby, G.D., Colotelo, A.C., Blouin-Demers, G., Cooke, S.J., 2011). Inadequate enforcement of management rules, paralleling with the geographical dispersion of fishing activities, appear to be the key factors allowing for high levels of illegal fishing, which also contribute to the decline of the fish stock with other mentioned issues.

1.4 Solutions

From the reconstruction of the fishing fleets after the World War II, expansion of fishing activities and employment of new technologies to the worldwide recognition of marine resource overexploitation, environmental degradation, and biodiversity loss in the 1990s, fishing activity and fisheries management have seen philosophies shift during the last 50 years. An urgent need for sustainable development of marine resources is have been seeking for a long time.

Management of small-scale fisheries has been notorious for the ineffectiveness because of its nature of open-access. This nature makes any intervention of allocating right for fishing activities pale and weak. Therefore, seeking solutions by only considering fishery sector seems nothing but barren. Furthermore, the importance of incorporating ecological and socioeconomics consideration in setting fisheries management regime has been increasingly acknowledged, which recognizes that in many instances neglecting the ripple effects of fishery policy has little possibility of success because of the limitation of narrower perspective and relative weak functionality(McGoodwin, J.R., 2001). Furthermore, given an effective management of marine resources was in place and the open-access have been mitigated by rules and regulations, fishers who were excluded from the sector are hardly willing to comply and would be further against the management of depriving their livelihood. This exclusion will incur more conflicts between fishers and lead to more activities of illegal fishing and destructive fishing (Béné, C., Hersoug, B., Allison, E.H., 2010).

Actions taken to date by resource managers to deal with overexploitation in small-scale fisheries, such as command and control regulation and vessel and gear buyback, have not been effective at dealing with the issue. As a matter of fact, a fisheries management with more effectiveness requires not only identifying problems but also realizing the relationship between proposed policies and the subsequent impacts. The management of fisheries really should be the management of its resource user, the fishers. Understanding the associated issues in its social, economic, and institutional dimension is just as important, if not more, as understanding the ecological or environmental components of fisheries. Unless the causes of issues and the accompanying impacts that associated with proposed policies are well thought out, any regulatory measures or other management strategy, such as marine protected areas (MPA), no-take areas, habitat restoration, enhancement and population manipulation (restocking, planting mangroves, stock enhancement, and culling, artificial reefs, protection of endangered and protected species) will just be simply a stop-gap measure in the short term since more people will continue to enter the fishery (Pomeroy, R.S., Andrew, N., 2011).

Fishers live in their villages or communities, and fishing activities are rarely carried out alone, the bond between people and fishing communities are very important in many aspects. Beyond the food, employment and income that are derived from fishing activities, there can be significant social and cultural benefits attached to the fishing community, such as collective decision-making. In Lao PDR, increased production from inland fisheries provided greater community income, and it was invested in infrastructures (health centers, markets) by the collective decision of all community members (Lorenzen, k.,Choulamany, X., Sultana, P., 2003). Any management of marine resource in the small-scale fisheries will not be considered as a success or complete if the relationship between fishing activities and fishers' villages or communities are not considered all together. Thus, a comprehensive understanding of fishing activities and the social bond existed in fishing community not only provides insights into how fisherman and their families make a living, but it also incorporates the impact of fishing community on their fishing activities. These considerations are important in terms of fishery management, since every dimension of consideration in small-scale fisheries, including material, relational, and subjective, have a significant influence on possibilities for improvement (Gough, I., McGregor, J.A., Camfield, L., 2007).

With the capability of accordance with different factors enables the decision maker to consider fisheries in the context of where fishers live and work in either household, communities or fishery-based economics. Thus, among all possible solutions, Community-based management and livelihood approach in fisheries management emerge as promising entry points for sustainable management of Small-scale fisheries. These comprehensive perspective and indeed more profound understanding of small-scale fisheries aim not only to address issues that under the direct control of fishery sector, but also improve the efficiency and effectiveness in where traditional fisheries management is lacking, such as compliance with rules and regulations, conflict reconciliation, risk reduction.

1.4.1 Community-Based Fisheries Management

The changing philosophies of the fisheries development process are reflected in changing approaches to fisheries resource management. Without colonization, various kinds of traditional and customary fisheries management regimes were in place in the Asia-Pacific region had sophisticated traditions, customs, and sea tenure systems consistent with conservation (Ruddle, K., Hviding, E., Johannes, R.E., 1992). While, during the colonial period, governance of coastal and marine resources was transferred from communities to local and national government bodies. In most colonies, centralized management agencies were established to control the level of exploitation, modernize fishing methods, and ensure exports back to the colonizing country (Pomeroy, R.S., 1995). The centralized approaches to management that began centuries ago in some countries continued under the neo-colonial regimes of newly independent nations as they consolidated power.

By appropriating control over fisheries management, national governments often neglect the capacities of coastal communities, often learned through long and difficult experience, to manage local fisheries to meet their needs. In many instances, the national government overestimated its ability to manage these same resources. When community-level institutional arrangements for coastal fisheries management are neglected and disvalued, the usual common-property resource management regimes have been replaced, in many cases, not by science-based government management but by open-access regimes. The conventional or centralized management approach has been dominated by the assumption that every fishery is characterized by intense competition, which will eventually lead to the so-called "tragedy of the commons." It also relies almost exclusively on scientific information and methods, as opposed to traditional and customary knowledge and management systems. This has led managers in the direction of tighter government controls over fisheries. Over time, these managements have become complicated, costly, and ineffective. Due to the recent failure of so many fisheries, the conventional management approach has been widely recognized as part of the problem rather than of the solution of marine resource overexploitation (Chusak, W., Vandergeest, P., 2010). On the biological side, the traditional approach fails to take into account the ecological complexities, especially in the case of tropical fisheries. On the socioeconomic side, bureaucrats and professionals have replaced actual resource users as resource managers. The actual resource users were excluded from the entire management process that was developed to improve the sustainability of local resource use. The centralized management approach, which makes little or no use of fishers' capacity to manage themselves and does little effective consultation of the resource users, is often not suited for developing countries with limited financial means and expertise to manage fisheries resources in widely dispersed fishing grounds (Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R., 2001).

Many international initiatives were brought during the 1990s, including the UN Conference on Environment and Development, the International Convention on Biological Diversity, the International Plan of Action for the Management of Fishing Capacity, and the Code of Conduct for Responsible Fisheries. These urged countries to encompass sustainable management of fisheries resources. A central element of these initiatives is the increased participation of resource users, transitioned from merely being consulted and receiving top-down information to participating in decision-making and interactive management of the resource that their livelihood depends upon.

Community-based resource management is a composition of several elements. It includes a group of people with common interests, mechanisms for effective and equitable management of conflict, community control and management of productive resources, local systems or mechanisms for capture and use of available resources, broadly distributed participation in control of resources within the community, and local accountability in management. It is a process by which the people themselves are given the opportunity as well as the responsibility to manage their resources, define their needs, goals, aspirations, and to make decisions that have an impact upon their well-being. As an approach, Community-based resource management emphasizes the capability, responsibility, and accountability of the community in terms of managing the local resource. It is inherently evolutionary, participatory, and local-specific with the consideration of the technical, socioeconomic, political and environmental elements integrated, which all have a significant impact on the local community. Many others also have a similar definition of Community-based resource management:

Community-based coastal resource management (CBCRM) is people-centered, community-oriented and resource- based. It starts from the basic premise that people have the innate capacity to understand and act on their problems. It begins where the people are, i.e., what the people already know, and builds on this knowledge to develop further their knowledge and create a consciousness…it strives for more active people's participation in the planning, implementation, and evaluation of coastal resources management programs. CBCRM allows each community to develop a management strategy which meets its particular needs and conditions, thus enabling a greater degree of flexibility and modification. A central theme of CBCRM is empowerment, specifically the control over and ability to manage productive resources in the interest of one's own family and community. It invokes a basic principle of control and accountability which maintains that control over an action should rest with the people who bear its consequences (Ferrer, E.M., Nozawa, C.M.C., 1997).

CBRM is an approach through which communities are given the opportunity and responsibility to manage in a sustained way the community resources, define or identify a number of resources and future needs, and their goals and aspirations, and make decisions affecting their common well-being as determined by technical, sociocultural, economic, political and environmental factors. It is a tool which facilitates the development of multilevel resource management skills vital to the realization of potentials of the community. Also, CBRM stands for people empowerment and achieving equity and sustainability in natural resource management. The key concepts are community, resources, management, access and control over resources, viable organizations and availability of suitable technology for resource management and utilization.

It is consensus-driven and geared towards achieving a balance of interests. The emphasis is on communities and at its core is the community organization. It is a process of governance and political decision-making, and it is geared towards the formation of partnerships and power-sharing…It can be argued that CBCRM is a politically negotiated process of making decisions on the ownership, control and overall policy directions of coastal resources…Questions of resource allocation, distribution of resource benefits and management arrangements among stakeholders will always have to be included. Moreover, CBCRMs central concern is the empowerment of groups and social actors and a sense of self-reliance at the micro-level that stimulates a more synergistic and dynamic linkage to the meso- and macro-levels (Pomeroy, R.S., Rivera-Guieb, R., 2005).

Overall, the concept of CBFM mostly refers to a system under which communities take a leading role in managing fisheries and adjacent coastal areas in partnership with, or with support from a promoting agency. It is a complex and dynamic system. To be more specific, the concept of CBFM is about communities, households, and individuals making a living, striving to reach their various consumption and living necessities through a sustainable management of fisheries resource which decided by collective knowledge and efficient enforcement. For achieving an effective management of small-scale fisheries, or any fisheries in general, it is fundamental to understand not only the fisheries but also the associated impacts on natural and socioeconomic. All fisheries, and especially community-based fisheries occur within the context of the community and reflect the economic and social goals and value of that community. As the individuals in fishing communities, fishers rely on healthy ecosystems and sustainable fishing activities for food, employment and income generation. A report by FAO identified the relationship between the effectiveness of fisheries management and compound force from social, economic, and institutional aspect, and highlighted as following:

- Social, economic, and institutional objectives and factors may be driving forces behind the need for fisheries management.
- The fishers' costs and benefits, whether to individuals or society, have social, economic and institutional impacts and implications.
- Social, economic, and institutional processes are all crucial for successful implementation of fisheries management.
- Social, economic, and institutional factors can play either supporting or constraining roles in whether management is effective or not.

As FAO indicated, communities gain their collective rights to manage local resources by organizing themselves to form larger organizations. It gives coastal communities and fishers primary responsibility for managing their coastal resources (Graham, J., Charles, A.T., Bull, A., 2006). This form of management is more localized and, therefore, the management techniques can take many different forms depending on regional differences and the nuances of different fisheries. For this reason, CBFM is not defined by one approach or set of guidelines that dictate its implementation. Instead, CBFM centers around the premise that community collaboration and local participation can be an extremely productive and accurate means of managing, monitoring, and maintaining coastal resources (Cobb, L., Gibson, C., Stauffer, P., 2007). The basic principles, ethics, and ideas maintained by CBFM are universally applicable to many different situations. With a more regional and integrated management approach, the benefits show in six aspects Pinkerton (1989):

1. Fisheries cooperate in planning to increase or conserve fish stock (sustainability)
2. Fishers share the costs and benefit in this management (economic equity)
3. There is better conflict resolution among fishers (intra-group social equity)
4. The position of fishers when dealing with other stakeholders is enhanced by being organized (inter-group social equity)
5. Fishers and government are willing to share data and understanding of the fisheries (knowledge sharing)
6. When fishers have more control over fisheries where they effectively own as a community, there is a greater trust between fishers and government, which bring two benefits:
    1) fishers have an incentive to take a longer term management perspective (sustainability)
    2) enforcement of the rule is more effective as these rules have a high level of acceptance and so compliance and self-enforcement are more effective and efficient. Hence the “transaction cost” of institutions for fisheries management are reduced (effective benefit)

Currently, fisheries are managed in most areas by a centralized or top-down management. This approach has no involvement of the local people who are mostly affected by the managed resource (Allison, E.H., Ellis, F., 2001; Pomeroy, R.S., Andrew, N., 2011). Fisheries issues such as Overfishing and overcapacity are the evidence of short-term interests of individuals conflicting with the long-term interests of the common good. They could also be evidence for lack of good management. While good management is dependent on good communication and shared information, which barely presented in the centralized management. Because in many situations precise information is fairly costly, and that makes manager no incentive to seek information. Therefore, the resource will suffer from inherently poor management in those situations. However, CBFM proposes that fishers and coastal communities should have the primary role in deciding how the resources of that community are managed. As stated in the Community Fisheries Management Handbook by Jennifer Graham:

"Fishermen and coastal communities, being the most dependent on coastal and marine resources, should have a large role in deciding how these resources should be managed. This idea fits within an emerging understanding that management decisions of all sorts are often best made at the most local level possible."

By empowering local interests, local relationships are accentuated in CBFM. Also, traditional fisheries management usually predominantly focus on certain value species while community forms of management incorporate much more ecosystem consideration when making a decision. Furthermore, CBFM achieves high productivity by combining scientific research with community involvement and local ecological knowledge to create monitoring programs specific to local areas.

While CBFM focuses on giving primary responsibility to the local communities, it is important to note that CBFM is not a panacea. It takes willingness, cooperation, involvement, and flexibility from community members to work together for the collective good. It is important that each stakeholder considers their decisions as they apply to the whole community and the health of the coastal resources. This collective responsibility for the long-term well-being of the natural resources depends on a type of responsible self-governance, dictated not by the achievement of maximum profits or harvest but instead by promoting stewardship and conservation ethic. CBFM seeks the conservation and preservation of ecosystem health, combined with the sustainable use of these local resources as seen fit by the community members. Removes the competitive spirit out of the fisheries and focuses the community on working for sustainability.

1.4.2 Livelihood Approach

The concept of livelihood mostly refers to a system that brings together the critical elements that have an impact upon vulnerability and resilience of the survival strategies of either individual or family or community. It is complex and dynamic, but the essence boils down to the day to day uncertainty of survival. To be more specific, the concept of livelihood is about individuals, households or communities making a living, striving to reach their various consumption and living necessities, coping with uncertainties and responding to external shock or opportunities (Haan, L., Zoomers, A., 2003). There are two ways to argue for livelihoods having a central place in fisheries management. The first of these is the social justice argument that the maintenance of employment and livelihoods in fisheries is important as part of society's moral responsibility to strive to ensure decent and meaningful lives for all its members. The second argument is more sensible. Given the large populations dependent on fisheries globally, their regional economic significance, and their contribution to regional and global food security and high-value trade in foodstuffs, it is in society's interest to ensure their livelihood sustainability.

Management of small-scale fisheries or fisheries in general, has been argued as a wicked problem (Jentoft, S., 2005), and the reasons that most fishery managements or governance are not developed with a sustaining livelihood of fisherman in mind are presented in the similar fashion: (1)the perception of a desirable and meaningful livelihood varies among the many actors and institutions related to it; (2) livelihoods in fisheries are constantly subject to modification and are never definitively ideal or sustainable; (3)problems with livelihoods are complicated by being embedded in larger social, cultural, political, economic, and ecological systems; (4) the diversity, complexity, and dynamics of fisheries livelihoods makes each case distinct; and, (5)fisheries governance, even that which is livelihoods sensitive, generally creates irreversible change for the ways in which fisherman make their living. In the literature of livelihood development, attempts were made to extend the work of Amartya Sen and Robert Chambers on the multidimensional nature of poverty (Béné, C., Hersoug, B., Allison, E.H., 2010). The fundamental work of these two scholars was challenging earlier approaches to poverty that are narrowly focused on income-based measurement and complement a social science understanding of the social complexity of small-scale fisheries (Jentoft, S., McCay, B.J., 2003). Following Sen and Chambers, livelihoods approaches share the basic assumption that very similar to poverty, livelihoods are diverse, multidimensional and comprised of varying sets of assets or capitals that people employ to cope with threats to their wellbeing. In keeping with Chambers' actor-centered approach, livelihoods approaches treat the poor as creative agents who seek to use their resources, regardless of how limited they might be, to meet their needs as effectively as possible. Livelihoods approaches may be applied at multiple scales (Scoones, I., 1999), but are most commonly applied at the household level (White and Ellison 2007, 160), which is a very reasonable application, since most people, fisherman to be more specific in the fishery, organize production, distribution, and reproduction at that level. Influenced by the great work of Ian Scoones, more attentions are paid to the practical experiences in managing livelihoods, at the levels of household, social networks and the community (Haan, L., Zoomers, A., 2003). Such experiences of the study of livelihoods are very specific in terms of actor, place, and context, with focuses on disturbances and local vulnerabilities, and process and adaption. Livelihoods approach also have origins in the sustainability discourse, with sustainable livelihoods a common pairing of concepts. This connection points to the idea that resilient livelihood strategies are those that can cope with threats and resist shocks. Resilient livelihoods are evidenced in fisheries by features such as the multiple gears and diverse knowledge that fishers possess, and the common integration of non-fisheries activities into their livelihood strategies (Allison, E.H., Ellis, F., 2001). The connection also indicates awareness of the fact that many rural livelihoods have a significant and direct reliance on ecosystem services, and there is a relationship between sustainable livelihoods and the sustainability of resource use. These are, of course, obvious features of fisheries.

Livelihoods approaches are typically organized around frameworks that establish a logical relationship among the key elements deemed to constitute a livelihood (Allison, E.H., Ellis, F., 2001; Scoones, I., 1999). These are schemas that attempt to capture the dynamic relationship between the creative attempts of factors to construct their livelihoods in the context of a variety of structuring forces. The application is interpreted through the use of assets that support livelihood. The range of these assets and how they are identified, alternatively as capitals or resources, varies from framework to framework. The commonly shared assets are natural, human, and social capital. For example, in small-scale fisheries, the social capital of kinship networks may facilitate access to financial capital in the form of loans or to natural capital in the form of access to fishing sites. In addition to these, some schemas lump together physical and financial capital, while others separate them. Political and cultural capital are additional variables that are occasionally used. The configuration of assets that different authors use represents different ways of splitting up the important variables that influence livelihood sustainability. Each type of asset refers to the resources that individuals and households may draw upon. They include, among others, access to social networks, natural resources, and money and material goods; personal health, skills and knowledge; and the degree to which one can lay claim to or mobilize socially significant meanings and symbols. Assets are not mutually exclusive and, instead, are deeply interconnected.

Fishers' livelihoods may be buffered by highly developed forms of community-based governance, or these may be virtually absent (Jentoft, S., 2005). Diversities between and within fisheries that affect livelihoods range across a host of these and other variables, such as technology, ecology, mobility, gender relationships of work, knowledge, market relationships, the degree of subsistence, institutional development and so on. All of these factors reinforce the fourth dimension of fisheries as a wicked problem that each particular problem is distinct, requiring governors to constantly refine their knowledge and adapt their responses. Approaching from the essence of fishing activities and understanding the stakeholder's livelihoods as a whole enable the livelihood approach a comprehensive concern and a holistic perspective. It is not merely concerning to monetary income but has close linkages to health, education, and capacity building for vulnerability reduction, which stem from both natural and socio-economic aspects. Livelihood approach does not intend to be an exact representation of the way the world is, but rather a manageable model to identify the most pressing constrains encountered by people regardless of which sector they are in. It also recognizes that solutions involve targeting not just the individual fisher but the whole household and its broader economic livelihood strategies. In order to settle down with less vulnerability and more sustainability, livelihood approach aims to not only resource and technical issues of overcapacity but the underlying non-resource-related issues of poverty, vulnerability, and marginalization in coastal households and communities, which are including food security, employment, income generation, health, improved quality of life, social development, community services, and infrastructure. The entrances of livelihood approach are going beyond fisheries sector and to the vast array of seemingly unrelated policies that will indirectly improve or have beneficial side effects for the fishing sector (Pomeroy, R.S., Parks, J., Mrakovcich, K.L., LaMonica, C., 2016).

Livelihood interventions are supposed to be implemented given the good consideration of target region, since the presence or the absence of one critical element may differentiate the success and failure of such project. For example, seaweed farming has found success in many locations when different variables for success and sustainability have been present, such as ideal growing conditions, access to markets, and proper training in place. Agricultural practices, such as animal husbandry, has also been tried with mixed success. However, these few alternative livelihood options may not be an appropriate alternative for every household due to the vast variety of demographic characteristics. It is critical to seek and analyze the determinant factors that have crucial impacts on the success rate and sustainability of specific livelihood projects, to fully achieve not only a better life for households but also an improved management of marine resources.

Sustaining livelihoods of fisherman and fishery management share a foundational complementarity. In epistemological terms, they are both approaches that fit with a post-equilibrium view of fisheries governance. This connection is becoming more transparent when they are coupled with the idea of wellbeing, which shows that livelihoods are diverse, complex and dynamic attempts to achieve a desirable way of living in particular social, cultural, economic, political and ecological contexts. (Jentoft, S., McCay, B.J., 2003)

1.5 Goals and Objectives

The overall goal of this research is to identify the impacts of Community-Based Fisheries Management (CBFM) projects on fishers' livelihood and sustainable fisheries management in the Philippines, Cambodia, and Bangladesh.

The objectives of this research are to:

1) Identify relationships between Community-Based Fisheries Management (CBFM) and fishers' livelihood and sustainable fisheries management.
2) Improve the application of meta-analysis to projects and programs focused on community-based fisheries management by identifying and developing proper effect sizes.
3) Make recommendation to improve the performance and sustainability of Community-Based Fisheries Management (CBFM) projects and its impact on fishers' livelihood.

1.6 Hypotheses

According to the contribution of fisheries activities to fisheries resources and livelihood, what effects (and to what extent) would be expected on the fishing household through Community-Based Fisheries Management (CBFM) are laid out as testable hypotheses and questions through this research:

Due to the crucial role of fish played in fishing community, in particular, for many regions where the fishing activities are mainly the way to support fishers' livelihood,

1. Has the condition of fisheries resource been impacted by Community-based fisheries projects and programs?
2. Do the Community-based fisheries projects and programs lead to improvement on fishers' livelihood?

CHAPTER II

DATA AND METHODOLOGY

2.1 Data

Due to the nature of meta-analysis, which is the research of previous researchers, not only the primary data of individual studies, also studies that provide the proper statistics which could be further processed as "effect sizes" (i.e. standardize mean difference of income) can be utilized as "data" for this meta-analysis research. All three studies that included in this dissertation are the analyses based on previous studies which provided such statistics. In reviewing the literature on projects and programs that focused on livelihoods in Asia, Cambodia, Bangladesh and the Philippines stand out with having most projects and programs on livelihoods that reported in English. Also, most of the authors of those reports are still active and are able to be contacted for more documents and complete reports. After searching from various literature including project reports, evaluation documents, publications, scientific journal articles, workshop papers, five, two, and thirteen projects and programs were chosen in Cambodia, Bangladesh and the Philippines, which covered twelve, nine, and thirty-one sites with the average sample size of 105, 60, 93 for each site respectively. As qualified projects, randomly selected household heads were individually interviewed for a household survey before and after the projects. Although the surveys were not identically designed, they did include common questions regarding the fisheries management and fishers' livelihood, which make them feasible for extraction of the responses of common questions and construction of effect sizes in the meta-analysis. As for the fishers in the control groups, they were randomly selected from all the non-members of CBFM and were asked to take the survey before and after the CBFM as well. Six, thirteen, and eight common indicators were extracted for the study of Cambodia, Bangladesh, and Philippines respectively, which facilitates further construction of effect sizes in the meta-analysis. In all three countries, performance indicators were constructed based on the sampling surveys which include both ordinal and nominal questions and employed in the meta-analysis.

2.2 Methodology

2.2.1. Literature Review

Tests of significance of combined results are known as an omnibus or, more commonly, nonparametric tests because these tests are independent of the distribution of data and rely only on the fact that p-values are uniformly distributed between zero and one. Thus, this advantage further expends the usability of the significance test. However, with a strong appeal in that they can be applied almost universally, significance test still suffers from an inability to provide estimates of the magnitude of the effects being tested. Thus, the significance test falls into a dilemma, which it discloses the probability of statistical significance of an intervention, but it is powerless to reveal what researchers care the most, that is, how much the intervention effects are? When significance test has been applied almost everywhere to support arguments statistically, it is necessary to remind ourselves that there might be too much attention were paid to statistical significance testing. Because tools are designed to serve their purpose, and knowing the probability of a null hypothesis is true is not exactly what researchers interested anyhow, statistical significance is a very artificial abstract, useful, but in a very narrow sense.

Back in 1952, Hans Eysenck started a wide-ranging debate in clinical psychology by arguing that psychotherapy have no beneficial effects on patients (Eysenck, H.J., 1952). By the mid-1970s, hundreds of studies of psychotherapy had produced a dizzying array of positive, null, and negative results, and reviews of those studies had failed to resolve the debate that Eysenck started. Until 1977, Gene V. Glass and his colleague, Mary Lee Smith published their results in a great work (Smith, M.L., Glass, G.V., 1977), concluding that psychotherapy was indeed effective, by statistically standardized and averaged treatment-control difference for 375 individual psychotherapy studies. They called this method "meta-analysis". At about the same year, similar statistical approaches to research synthesis were being crafted by Rosenthal and Rubin in the area of interpersonal expectancy effects and by Schmidt and Hunter in the area of validity generalization of employment tests. After these, the term meta-analysis has come to encompass all of the methods and techniques of quantitative research synthesis developed by these and other researchers. Since the pioneering works in the 1970s, thousands of meta-analyses have been conducted and great improvements have been made in the methodology of meta-analysis itself.

Meta-analyses have been implemented in a vast variety of disciplines nowadays. Before the introduction to social science, meta-analysis is mostly used to assess the clinical effectiveness of healthcare interventions, by combing data from two or more randomized control trials. The Cochrane Collaboration has published the results of over 4,000 meta-analyses as of 2009, which synthesized data on treatments in all areas of health care including headaches, cancer, allergies, cardiovascular disease, pain prevention, and depression. In the field of pharmacy, companies usually conduct a series of studies to assess the efficacy of a certain drug. They use meta-analysis to synthesize the data from these studies, yielding a more powerful test (and more precise estimate) of the drug's effect. In the field of ecology, meta-analyses are being used to identify the environmental impact of wind farms, biotic resistance to exotic plant invasion, the effects of changes in the marine food chain, plant reactions to global climate change, the effectiveness of conservation management interventions.

With the considerable number of implementations in natural science, meta-analysis has drawn the increasing attention in social science later on as well. In the field of education, meta-analysis has been applied to topics as diverse as the comparison of distance education with traditional classroom learning, assessment of the impact of schooling on developing economies, and the relationship between teacher credentials and student achievement. Even in the field of criminology, government agencies have funded meta-analyses to examine the relative effectiveness of various programs in reducing criminal behavior, which includes initiatives to prevent delinquency, reduce recidivism, assess the effectiveness of different strategies for police patrols. In business, meta-analyses have been used to guide practices for the reduction of absenteeism, turnover, and counterproductive behavior, and to assess the effectiveness of programs used to train employees.

Meta-analysis is a study which collecting and selecting previous studies that qualified certain criteria, coding and analyzing data extracted from nominees, and finally providing suggestions to targeted decision-makers. Such studies bring together individual results from underlying studies in order to determine if and where broader generalizations can be made than would have been possible by individual case studies. Therefore, meta-analysis is the new research by synthesizing and analyzing previous researches with the distinctive merits, which include 1) directly focused on the direction and magnitude of the effect caused by interventions; 2) examines pattern of evidence across all studies by constructing proper effect sizes; 3) investigate any perceivable effect to check the degree of consistency of the underlying effect sizes; 4) investigate and identify the categorical pattern, and test whether variation among studies in effect size is associated with true differences in study methods or participants by applying categorical analysis. It worth mentioning that the meta-analyses that been used in this research are primarily the meta-analyses of effect size. That is, analyses where each study yields an estimate of same statistics (standardized mean difference, response ratio, etc.) and the ultimate goal is to analyze the dispersion in these effects and the seeking the cause and magnitude, if there is any, of the heterogeneity in effect sizes. The meta-analyses in this research directly target on the magnitude and the heterogeneity analysis of effect sizes, and the relation between the effect sizes and characteristics of fishing communities. As of to date, meta-analysis has been applied to various research topics. Although its rare application in the fishery, or resource economics in general, the similarities in design and practice between the classic applications in psychology and other experimental sciences and the local/regional pilot programs of fisheries carried out by governments and NGOs make meta-analysis a very promising and relevant approach here.

2.2.2 Meta-Analysis

In the meta-analyses that employed in this research, the mean scores of each indicator in both treatment group and control group of selected projects and programs in three countries before and after CBFM were extracted for effect size construction. The effect sizes (ES) that will be used in the meta-analysis are constructed in a different form based on the statistics reported from the individual studies.

In order to obtain the most precise estimate of the overall mean (to minimize the variance) and comply with large sample theory which states that studies with large samples have more precision, a weighted mean will be assigned to each study. The way of distributing weight might be varied in different researches, the most common approach will be applied in this dissertation, which defines weight (w_i) as the inverse of the variance (v_i) of its mean score and calculated as

$$w_i = \frac{1}{v_i} \tag{2.1}$$

As for the variance v_i, they were usually not reported explicitly in project report. Thus, they will be approximated based on the form of effect size each meta-analysis employed. Considering the heterogeneity of true effect size based on various settings of selected projects and programs, random-effects model was used across all three meta-analyses. In other word, the true effect size is different across all studies and the variance has two components, population variability and the sampling deviation. Because it would be unlikely that all the studies were functionally equivalent. Especially, the interventions in these independent studies would have differed in ways that would have impacted on the results, and therefore the assumption of a common effect size would not be appropriate in this research that based on the different surveys across different sites. Furthermore, logic dictates that the magnitude of the impact might very depending on the sites of the study, quality of survey design and implementations of intervention, cognitive level of respondents, the attitude of respondents towards the project and program, and so on. Indeed, we might not even aware what covariates are related to the size of the effect regardless. Thus, the random-effects model, which has an additional between-study variance in addition to the original within-study variance, fits the scenario, where the true effects could also vary from study to study due to the specific condition of respondents and process of implementation, much more precisely. In other words, the effect sizes in the studies that were performed are assumed to represent a random sample of these effect sizes.

So, there are two parts of the variance of effect sizes that will be captured and estimated in the random effect model. They are the within-study variance v_i that caused by sampling error and between-study variance τ^2 that reflects the true differences among effect sizes underlying different studies due to the mixes of participants and the implementations of interventions. The study's total variances are,

$$V_{ij} = v_{ij} + \tau_i^2 \tag{2.2}$$

For the between-study variance, the way of estimating τ_i^2 is the method of moments or the DerSimonian and Laird method as follows,

$$\tau_i^2 = \frac{Q_i - (k-1)}{\sum_{j=1}^{k} w_{ij} - \frac{\sum_{j=1}^{k} {w_{ij}}^2}{\sum_{j=1}^{k} w_{ij}}} \tag{2.3}$$

Q is the statistic that describes the summation of observed weighted square of the deviation of each effect size from the mean, computed as,

$$Q_i = \sum_{j=1}^{k} w_{ij}\left[ES_{ij})\right]^2 - \frac{\left[\sum_{j=1}^{k} w_{ij}\,(ES_{ij})\right]^2}{\sum_{j=1}^{k} w_{ij}} \tag{2.4}$$

At this moment, we have incorporated both within and between study variability in the random-effect model as we got both values of v_i and τ_i^2 and are able to compute the total variance using (2). As soon as the calculation of total variance was completed, the weight assigned to each study under random-effect model need to be re-calculated as,

$$W_i = \frac{1}{V_i} \tag{2.5}$$

Moreover, the overall mean effect under the random-effect model was then computed as,

$$\overline{\overline{\mathrm{ES}}} = \frac{\sum_{i=1}^{k} W_i(ES_i)}{\sum_{i=1}^{k} W_i} \tag{2.6}$$

The variance of the overall mean effect of each indicator is estimated as the reciprocal of the sum of the weights, and the estimated standard error of the overall mean effect of each indicator is then the square root of the variance, as follows,

$$V_{\overline{\overline{\mathrm{ES}}}} = \frac{1}{\sum_{i=1}^{k} W_i} \tag{2.7}$$

$$SE_{\overline{\overline{\mathrm{ES}}}} = \sqrt{V_{\overline{\overline{\mathrm{ES}}}}} \tag{2.8}$$

Then, the 95% confidence interval of the overall mean effect would be computed as

$$LL_{\overline{\overline{\mathrm{ES}}}} = \overline{\overline{\mathrm{ES}}} - 1.96 * SE_{\overline{\overline{\mathrm{ES}}}} \tag{2.9}$$

$$UL_{\overline{\overline{\mathrm{ES}}}} = \overline{\overline{\mathrm{ES}}} + 1.96 * SE_{\overline{\overline{\mathrm{ES}}}} \tag{2.10}$$

2.2.3. Heterogeneity Analysis

Although having the magnitude and the significance of the overall mean effect for each indicator briefly exposes the general performance of specific project and program, the evidence that are indicating if the true effects are consistent across studies from different sites are still unveiled. In the assumption of the random-effects model that will be applied in this research, the true effect sizes may vary from study to study due to the mixes of participants and the implementations of interventions. It would be much more informative if any heterogeneity underlying effect sizes could be identified and quantified explicitly. In the primary study, for the same purpose, we can compute the variance of the effects and investigate what proportion of variance can be explained by covariates. While, our goal is similar in the meta-analysis, in the sense that we want to describe the variation, using indices such as the standard deviation and variance.

However, this process will get more complicated and be frustrated by some limitations and unclearness in the definition. Since when we discuss the heterogeneity in effect sizes, we mean the variation in the true effect sizes, however, the variation that was observed in our research is partly spurious, incorporating two parts, true differences among effect sizes and random error as well. For example, suppose for a moment that all studies in the analysis share the same true effect size, so we should have zero heterogeneity, but we would not expect the observed effects to be perfectly identical to each other. Rather, because of the existence of the within-study error, we would expect each effect to fall within some range of the common effect. As in the random-effects model that will be employed in this research, which assume that the true effect size does vary from one study to another, we must be vigilant and clearly partitioned the observed variation into these two components to identify and investigate what is and how does each part make a difference in the performance of the livelihood project and program in the three countries.

The mechanism that we use to identify the true difference or between-studies variation from the observed variation is as follows:

1. we compute the total amount of study-to-study variation that is observed.
2. We estimate how much the observed effects would be expected to vary from each other if the true effect was the same across all studies. (between-study variance is zero)
3. The excess variation, if there is any, is assumed to reflect real differences in effect size, which is the heterogeneity that we supposed to seek.

For the first step, Q-statisitc provides the summation of observed weighted square of the deviation of each effect size from the mean (WSS), and it is on a standardized scale as shown in (7), which means that it is not affected by the metric of the effect size. For the second step, because Q is a standardized measure as mentioned above, the expected value of Q based on within-study error does not depend on the metric of effect size, and it is simply the degrees of freedom as shown in (8). With the total amount of study-to-study variation that is observed and the expected value of Q based on within-study error, the difference between the two will be the excess variation, which reflects the real differences in effect size, that is the heterogeneity we are looking for. Also, Q statistic is distributed as a Chi-Square with $k-1$ degree of freedom where k stands for the number of effect sizes. A low p value or a large Chi-squared statistic relative to its degree of freedom indicates more evidence of existence of heterogeneity of effects sizes (variation in effect estimates beyond chance). If homogeneity assumption is rejected, then the distribution of effect sizes is assumed to be heterogeneous, which turns out that there is real difference between studies on the estimation of mean effect sizes. However, the Q test is only capable of telling the presence versus the absence of heterogeneity, it does not report on the magnitude of such heterogeneity. So, if Q statistics is not statistically significant, the assumption of homogeneity can be neither rejected nor accepted as all other hypotheses testing and none of information about how much heterogeneity was revealed.

It is important to consider to what extent the calculated effect sizes from each study are heterogeneous rather than the simple presence or absence of heterogeneity even when the Q test is showing significant result. It is prevalence in clinical trials that methodological diversity always occurs in a meta-analysis, statistical heterogeneity is nearly inevitable (Higgins, J.P.T., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003). Thus, the test for heterogeneity is irrelevant to the choice of analysis in some cases. Heterogeneity will always exist whether it happens to be detected using certain statistical test. Methods have been developed for quantifying inconsistency across studies that move the focus away from testing whether heterogeneity is present to assessing its impact on the meta-analysis.

At this point, Julian Higgins developed an alternative approach that quantifies the effect of heterogeneity, providing a measure (statistic I^2) of not only direction, but also magnitude of inconsistency in the studies' results. The statistic I^2describes the percentage of total variation across studies that is due to heterogeneity rather than chance and it is calculated as,

$$I^2 = \frac{Q - df}{Q} * 100\% \qquad (2.11)$$

I^2 is presented as a function of homogeneity test statistic Q, which is a very legitimate augment since Q is Cochran's heterogeneity statistic and I^2 stands for how much variability are presented relative to the degree of freedom. What this ratio describing is indeed the ratio of excess dispersion to total dispersion. Since there is no negative variability, the values of I^2 lies between 0% and 100%. A value of 0% indicates no observed heterogeneity, and larger values show increasing heterogeneity. The general rule of thumb applying this test is showing as follows,

75%: large heterogeneity

50%: moderate heterogeneity

25%: low heterogeneity

I^2 statistic preforms similarly as the Q test from an inferential respective. However, I^2 statistic has specific advantages as oppose to the classical Q test. First, it is more friendly to be presented and easily interpretable due to its percentage form and does not depend on the degree of freedom of the effect sizes. Second advantage is that I^2statistic reveals more information comparing to the dichotomous conclusion derived from Q test, which reports either presence or absence of heterogeneity. The I^2 statistic and its confidence interval allow us to assess both the statistical significance and the extent of heterogeneity at the same time. Thus I^2 statistic and its confidence interval are highly recommended in doing meta-analysis (Huedo-Medina, T.B., Sánchez-Meca, J., Marín-Martínez, F., Botella, J., 2006). But it worth noting that I^2 statistic is a descriptive statistic and not an estimate of any underlying quantity because the within-study variances vary from one study to another (MA).

2.2.4. Categorical Analysis

When heterogeneity is revealed and quantified after applying Q test and examining I^2 statistic, a more essential question emerges, which is why the effect sizes or more general and explicit, effectiveness of projects and programs differ from one to another. Figuring this ultimate information is very powerful and efficient for performance improvement on any further similar projects and programs.

Before actual proceed this seeking process, we need to thoroughly inspect the individual studies included, combing with the results come from the process of heterogeneity analysis, Q test and I^2 statistic to generate an initial assumption of the origin of the heterogeneity across effect sizes. In other words, certain effect size would be affected more by one specific characteristic than other ones, for example, income level, as a characteristic of survey sample, would have more impact on the effect size of alternative employment creation. For another example, duration of the projects and programs would have bigger impact on the effect size of awareness raising. For seeking the fundamental cause of the heterogeneity, categorization of all studies into different groups according to our initial assumption will be made, then we can proceed a categorical analysis, akin to the ANOVA in primary study, by calculating the weighted sum of square (WSS) of each group about their mean, the summation of all WSS as the within group weighted sum of square (within-WSS), and the weighted sum of square of subgroup means about the grand mean (between-WSS). Then we are going to test if the difference between groups is statistically significant, and if it is, which indicate that our initial assumption indeed is explaining the cause of heterogeneity in effect sizes. The only difference between doing ANOVA in a primary study and categorical analysis in a meta-analysis lies in the fact that we are working with subgroups of studies in meta-analysis rather than groups of subjects in primary study.

Categorical analysis utilizes the Q_{btw} statistic as shown below, it used to test the null hypothesis that the weighted mean of distribution of effect sizes are the same for two groups.

$$Q_{btw} = \sum_{g=1}^{c} \sum_{p=1}^{n_g} w_{pg} \left[ES_{pg}\right]^2 - \frac{\left[\sum_{p=1}^{n_g} w_{pg}\, ES_{pg}\right]^2}{\sum_{p=1}^{n_g} w_{pg}} \tag{2.12}$$

where g is the number of groups, n_g is the number of projects and programs in the group g, $\ln(RR_{pg})$ stands for the effect size of pth program or project in the group g, w_{pg} stands for the weight of the effect size of pth program or project in the group g.

Having this extra level of precision enables us to provide the range that the true difference between subgroups will fall, and all this information will help us in providing a critical suggestion for improving the performance of such effect sizes in future projects and programs.

CHAPTER III

THE IMPACT OF COMMUNITY-BASED FISHERIES MANAGEMENT (CBFM) ON FISHERIES AND FISHER'S LIVELIHOOD IN CAMBODIA

3.1 Introduction

The inland fisheries of Cambodia are among the largest and most substantial in the world (Keskinen, Marko, Kummu, M., Salmivaara, A., Someth, P., Lauri, H., Moel, H.d., Ward, P., Pech, S., 2013). In a country that sits in the 4th rank of inland fisheries productivity, the overall fisheries production of Cambodia is estimated as 600,000 tons in 2011, made up of 73% inland fisheries, 15% marine fisheries, and 12% aquaculture (FiA, 2012). With its dominant proportion, the inland fisheries in Cambodia have the highest catch, as well as consumption, per capita in the world (Baran, E., 2010). The Tonle Sap Lake is famous for its unique flood pulse system and high fish productivity. As of 2009, inland fisheries contribute 76 percent of Cambodia's total fish catch (515,000 tons) (FAO, 2011), of which the Tonle Sap Great Lake provides about 60 percent (Baird, I.G., Flaherty, M.S., 2005; Lieng, S., Van Zalinge, N., 2001). Inland Fisheries Research and Development Institute (IFReDI) estimated that the inland fisheries alone contributed 6.7% (8% to 12% for total fish production) to the GDP of Cambodia with the total economic value of freshwater fish reached USD 1 billion (FiA, 2009; IFReDI, 2013). In addition, the variety of fisheries in Cambodia also sets itself apart from other countries by having 955 different fish species and employing at least 150 kinds of fishing gear (Matschullat, J., Freiberg, B., 2014).

With such productivity and variety, Cambodia fisheries contribute to food security and livelihood significantly (Ahmed, M., Navy, H., Vuthy, L., Tiongco, M., 1998; Duc S'an, T., Todd, B.H., 2003). FAO reported that 53.2% (75.6 kg per capita annually) of animal protein intake are from fish consumption in Cambodia in 2011(FAO, 2011). In addition to the contribution that fish protein makes to brain development in unborn babies and infants (Cogels, O., 2004), especially in a country still plagued by high rates of childhood malnutrition (Allison, E.H., 2011). Fisheries resources play a significance role in rural livelihoods and are especially critical for the poor (Béné, C., Hersoug, B., Allison, E.H., 2010). Regarding employment, the fisheries sector provides income and employment to 46% (6.7 million) of the total population as full-time, part-time, and seasonal work (ADB, 2010; FiA, 2009). Over 1.5 million people derive their livelihoods in five provinces around the Tonle Sap Lake (Ahmed, M., Navy, H., Vuthy, L., Tiongco, M., 1998).

To conserve and prevent the further collapse of fisheries resources in the Tonle Sap Lake, the Royal Cambodian Government has stepped in and created a policy environment that promotes natural resource protection and management. A wide range of policies has been drafted and passed since the late 1990s (Van Acker, F., 2010). Having recognized the crucial role of local communities in managing common freshwater resources, these policies, and following programs are mainly functional through the formation of Community-based Fisheries (CF), which are intended to be fundamental for securing and sustaining rural livelihoods in a timely fashion.

It is crucial to regularly evaluate the impacts of community-based fisheries management (CBFM) projects to enable meaningful feedback of information necessary for further management adjustment. Although previous reviews have attempted to evaluate the performance of individual CBFM project in Cambodia (Oxfam, 2003; Try, T., 2003; Viner, K., Ahmed, M., Bjlrndal, T., Lorenzen, K., 2006), synthesis studies and thorough understanding of what effects CBFM have and how effective CBFM is, especially from the perspective of the local resource users, are seldom accomplished. The objective of this paper is to present the results of a study to assess the impacts of CBFM projects in Cambodia, using meta-analyses, on sustainable management of fisheries resources and fisher's livelihood.

3.2 Community-Based Fisheries Management (CBFM)

The natural resources in Cambodia were relatively unexploited compared to other countries in Southeast Asia until the 1990s. Warfare broke out in Cambodia that lasted nearly 20 years (1975-1991) and unintentionally excluded most natural resources from the acute depletion associated with agricultural expansion and economic growth that occurred throughout much of Southeast Asia (Degen, P., Van Acker, F., van Zalinge, N., Thuok, N., Vuthy, L., 2000; Le Billon, P., 2000; Tyner, J.A., Lancaster, G., 2008). However, the ever-increasing pressure originating from the commercial demand on natural resources after the war significantly aggravated the threats to the livelihood and food security of the Cambodian people. High levels of resource extraction began with deforestation and overfishing, and have since incorporated other natural resources (Cock, A., 2010; Un, K., So, S., 2009). Inland fisheries, for example, had seen a dramatic decline with between 5 and 30 percent stock left in less than twenty years (Bush, S.R., 2008; PMCR, 2008; Salayo, N., Garces, L., Pido, M., Viswanathan, K., Pomeroy, R., Ahmed, M., Siason, I., Seng, K., Masae, A., 2008). Moreover, considering a 1.6% average growth rate in agricultural employment (Royal Government of Cambodia, 2003), limited land availability, and a rapidly increasing population, more and more people are resorting to the nearly depleted fishery, a resource with open access, to make a living. The open access not only escalates several ecological problems that fisheries encountered all along, but also contribute to the tendency of some social issues to increase, such as illegal and destructive fishing, the increasingly visible of conflict among fishers, and the long-standing tensions between commercial and subsistence fishers on the lake.

Community-based fisheries management (CBFM) has drawn considerable attention worldwide because this approach provides an opportunity to the local resource users to participating in fisheries resource management (Hanna, S., 1995; Jentoft, S., 2005; Nielsen J., Vedsmand, T., 1999; Pomeroy, R.S., 1994). This approach addresses direct management and development issues of the fisheries, as well as issues outside of the fisheries but direct consequence to fishers and fishing communities, such as rural economic and community development. The purest form of CBFM is a system in which fishers and their communities exercise primary responsibility for stewardship and management, including taking part in decision-making on all aspects of management, such as access, harvest, and monitoring (Weber Michael L. and Iudicello Suzanne, 2005). It defines a type of fisheries management which is created by fishers under their initiatives, and as its characteristics indicate, the resources have been delegated to local resource user to manage in a sustainable manner and contributing to rural poverty alleviation (Yamamoto, T., 1996). Thompson (1999) summarized the six benefits in CBFM as sustainability, economic equity, social equity (both inter and intra-groups), knowledge sharing, and security of tenure on resources.

Although CBFM enables resource users to better share the benefits of the fisheries, in the absence of sustainable management and effective enforcement of regulations there is a possibility that such open access will lead to overfishing and the designated areas may be accessed by outsiders, causing conflict between communities and commercial fishers (Mustafa, M.G., Halls, A.S. 2007; Weber Michael L., Iudicello Suzanne, 2005). Researchers of CBFM in Lao PDR indicated that community fisheries could be more effective in conserving fish stocks if distinct ownership of resources is in place and the CBFM can obtain support from the government (Baird, I.G., Flaherty, M.S., 2005). The food security and livelihoods of people who depend on the Tonle Sap Lake ecosystem were expected to be improved by this social and ecological alteration through CBFM.

3.3 Methodology

3.3.1 Study selection and data collection

For the impacts assessment of CBFM for multiple projects, several criteria of project selection were established. (1) Projects with completed reports or assessment studies. (2) Projects targeted on inland fisheries and the main approach was community-based management. (4) Projects reports or studies incorporated quantitative analysis based on the household survey before and after the intervention. Also, because a quasi-experimental with difference-in-difference (DID) method (Abadie, A., 2005; Lechner, M., 2010) was used in effect size construction to counteract factors that might have impacts upon certain indicators even there had been no intervention at all. Thus, (5) other than the "treatment group" which consisted of members of the CBFM, the "control group" which consisted of a non-member of CBFM was also required for each project. (6) Although meta-analysis does not necessarily require the whole data set of project studies, the mean, standard deviation, and sample size are required for each project study for properly synthesis.

After searching from various literature including project reports, evaluation documents, publications, scientific journal articles, workshop papers, five projects were chosen and their project studies were employed in this meta-analyses as individual studies (Table 1 and 2). As qualified projects, they all targeted the regions around the Tonle Sap Lake including the provinces of Pursat, Kandal, Kampong Chhnang, and Siem Reap. Also, randomly selected household heads were individually interviewed for a household survey before and after the projects. Although the surveys were not identically designed, they did include common questions regarding the fisheries management and fishers' livelihood, which make them feasible for extraction of the responses of common questions and construction of effect sizes in the meta-analysis. As for the fishers in the control groups, they were randomly selected from all the non-members of CBFM in the Tonle Sap lake and were asked to take the survey before and after the CBFM.

Table 1. Projects Included in The Meta-Analysis in Cambodia

No.	Project	Initiator/Funder	Duration
1	The WorldFish Center Project	DOF, IFReDI	1999-2005
2	Community Fishery Project	CCF, CCD	1996-2001
3	Tonle Sap Environmental Management Project	ADB	2003-2007
4	Conservation & Management of Kampong Perak Fish Sanctuary	CI	2004-2007
5	Participatory Natural Resource Management in the Tonle Sap Region	FAO	1998-2007

Table 2. Sites of Implementation In Each Project And Their Sample Size In Cambodia.

Project	Village	Province	Sample Size

1	Anlong Raing, Wile Prek Trabek, Ta Skor	Pursat, Kandal	270
2	Kanlen Phe, Onloung Ork, Korng Mes	Kanpong Chhnang	74
3	Preak Takong, Preak Tavong	Pursat	74
4	Kampong Preak	Pursat	60
5	Dey Kraham, Thnot Kambot, Kok Kdol	Siem Reap	60

1. World Fish Center Project

This project was developed and implemented by DOF/IFReDI of Cambodia. It aimed for reducing overcapacity of small-scale fisheries in Southeast Asia and examining where fisheries conflicts may arise and ameliorating it through CBFM (Seng, K., Song, S.L., Navy, H., Leang, S., 2005).

2. Community Fishery Project

This project was supported by Cambodian Capture Fishery (CCF) and Community Capacity for Development (CCD). It aimed to help capacity building on the community fishery committees to make sensible community fishery management plan and to empower the communities to take control of sustainable fishery resources management with proper fishery law and community fisheries regulation enforcement (Vann, 2005).

3. Tonle Sap Environmental Management Project

This project was supported by ADB for enhancing and developing the capacity for natural resource management coordination and planning, community-based natural resource management and biodiversity conservation in Tonle Sap Biosphere Reserve in Cambodia (ADB, 2010).

4. Conservation and Management of Kampong Perak Fish Sanctuary

This project is supported by Conservation International, and it aimed to improves the fish stock during the breeding season in Fish Sanctuary and around the Tonle Sap Lake and to conserve the endangered species with refuges from the intensive fishing pressure during the dry season. The project was also focused on improving the awareness of local people on the socio-economic impact of fisheries resources utilization through participatory community-based fisheries management (Nith, C., 2009).

5. Participatory Natural Resource Management in the Tonle Sap Region

This FAO project was aimed at addressing natural resources management issues around the Tonle Sap Lake. It focused on conducting research and collecting data on the fishing communities around the Tonle Sap Lake, in addition to facilitating community organization management planning and implementation (Evans, P., 2002; Marschke, M., 2012).

Also, all regions around the Tonle Sap Lake covered in these studies are impacted by the community-based fisheries promotion policy during the same period (1996-2009). With the average sample size of 105.2 (Table 2), six common indicators (Table 3) were extracted from five project studies, which could be further modified as effect sizes (Response Ratio) in the meta-analysis (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Hedges, L.V., Gurevitch, J., Curtis, P.S., 1999).

Table 3. The Indicators Used to Evaluate The Impacts Of CBFM Projects In Cambodia.

Indicators (Mean)	Definition
asset value	Household assets included house, boat, housing appliance, and electronic appliance.
income	Household gross income was computed by summing up all the returns to family labor in one year.

expenditure	Household expenditure was calculated by summing up all costs that one household spent in one year.
land size	Land size owned by a household.
fishing gear	The quantity of fishing gear owned by each household.
fish catch	The amount of fish caught for each household in a year.

3.3.2 Meta-analysis

It worth mentioning that the meta-analyses used in this research are the meta-analyses of effect sizes and the goals are to discover the direction and magnitude of the effect sizes, analyze the dispersion in these effects as well as their magnitude and causes (Hedges, L.V., Olkin, I., 1985; Card, N.A., 2012). Unlike the regression analysis which mainly investigates the relationship between dependent variables and independent variables, meta-analysis directly targets on the magnitude and the heterogeneity analysis of effect sizes across different studies.

In this meta-analysis, the mean and standard deviation of indicators before and after the intervention in both treatment group and control group were extracted from project studies. Each project study was treated as an independent study because there is no single site included in two projects. The metric of effect size used in this meta-analysis was constructed in the form of Response Ratio (RR) which provides information about the magnitude and trajectory of change evident across all individual studies (Hedges, L.V., Olkin, I.,1985; Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009). It quantifies the proportionate change as a result of the interventions (Hedge, L.V., Gurevitch, J., Curtis, P.S., 1999; Card, N.A., 2012).

By incorporating the difference in means of indicators before and after intervention in control group, the impacts of CBFM were measured more precisely with limiting the influences that were not caused by projects but also affect the indicators. This integration has rarely been incorporated in the project studies in Southeast Asia fisheries, even for the big projects (CRMP, 2004; FISH, 2010; Mustafa, M.G. & Halls, A.S., 2007). It is worth investigating what impact of incorporating difference in the control group in the meta-analysis on the effect sizes of CBFM. The comparison of effect size for each indicator with and without control group difference integration was presented in the discussion chapter.

The original response ratio was calculated as the ratio of mean after intervention over mean before intervention for each indicator in the treatment group only (Hedges, L.V., Olkin, I., 1985; Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Card, N.A., 2012), as shown below,

$$Response\ Ratio_{ij} = \frac{\overline{X_{t\ ij}^{a}}}{\overline{X_{t\ ij}^{b}}} \tag{3.1}$$

In order to counteract the influences that were not caused by projects but also affecting the indicators, a difference in the control group was introduced and added to the denominator. Thus, the modified Response Ratio (RR) and its logarithm transformation were computed and used for all following discussion,

$$RR_{ij} = \frac{\overline{X_{t\ ij}^{a}}}{\overline{X_{t\ ij}^{b}} + (\overline{X_{c\ ij}^{a}} - \overline{X_{c\ ij}^{b}})} \tag{3.2}$$

$$\ln(RR_{ij}) = \ln\left[\frac{\overline{X_{t\ ij}^{a}}}{\overline{X_{t\ ij}^{b}} + (\overline{X_{c\ ij}^{a}} - \overline{X_{c\ ij}^{b}})}\right] \tag{3.3}$$

where X is the mean of indicator, t and c indicate the different groups (treatment and control), a and b indicate different time point (after and before intervention), i indicates the number of indicators and j indicates the number of project. (e.g. $\overline{X_{t\ ij}^{a}}$ stands for the mean of indicator i in the treatment group of projects j after the intervention.)

The natural logarithm transformation of response ratio was applied in the meta-analyses because it has two advantages (Hedges, L.V., Gurevitch, J., Curtis, P.S., 1999): (1) the logarithm linearizes the metric, treating deviations in the numerator the same as deviations in the denominator. That is, while the ratio is affected more by changes in the denominator (especially when the denominator is small), the log ratio is affected equally by changes in either numerator or denominator (3.3). The sampling distribution of response ratio is skewed, and the distribution of its log form is much more normal in small samples. The log response ratio was calculated and used to perform all steps in the meta-analyses (Hedges, L.V., Olkin, I., 1985). Moreover, the results were converted back to the metric of Response Ratio (RR) for discussion. In this study, thirty effect sizes in total were calculated using equation (3.3) since there were five projects and each one includes six indicators. To obtain the most precise estimate (minimal variance) of the summary effect size for each indicator across all projects, and comply with large sample theory which states that studies with large samples have more precision, each effect size, $\ln(RR_{ij})$, was weighted by the inverse of the its sampling variance as,

$$w_{ij} = \frac{1}{v_{ij}} \qquad (3.4)$$

The sample variance v_{ij} was estimated by an asymptotic distribution based on the sample size and standard deviation of before and after project survey for both treatment and control groups (Lajeunesse, M.J., 2011) as shown

$$v_{ij} = \left(\frac{1}{\overline{\overline{X_{t\ ij}^{a}}}}\right)^2 \left[\frac{\left(SD_{t\ ij}^{a}\right)^2}{N_{t\ j}^{a}}\right] + C_{ij} \tag{3.5}$$

$$C_{ij} = \left(\frac{1}{\overline{\overline{X_{t\ ij}^{a}} + \overline{X_{c\ ij}^{a}} - \overline{X_{c\ ij}^{b}}}}\right)^2 \left[\frac{\left(SD_{t\ ij}^{b}\right)^2 + \left(SD_{c\ ij}^{a}\right)^2 - \left(SD_{c\ ij}^{b}\right)^2}{N_{t\ j}^{b}}\right] \tag{3.6}$$

where *N* and *SD* are the sample size and standard deviation of the household survey, respectively, also $N_{t\ j}^{a} = N_{t\ j}^{b} = N_{c\ j}^{a} = N_{c\ j}^{b}$, *a* and *b* signify the time point of (after and before) project, *i* and the *j* stand for the specific indicator and which project they are in.

Thus, the weighted mean effect size of each indicator across all projects can be calculated by using the effect sizes of the same indicator in all projects and their weights as shown,

$$\overline{\ln(RR_i)} = \frac{\sum_{j=1}^{k} w_{ij} \ln(RR_{ij})}{\sum_{j=1}^{k} w_{ij}} \tag{3.7}$$

However, it is unrealistic to assume that any factor which can have an impact on the indicators are the same across all projects. Thus all projects included were unlikely functional equivalent. In other words, the true effect size of each indicator was not identical in each project, and any difference was not merely due to the sampling deviation. Thus, the interventions in these independent studies would have differed in ways that would have impacted on the effect sizes, and therefore the assumption of a common effect size (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Lipsey, M.W. & Wilson, D.B., 2001) would not be appropriate in this meta-analysis. Furthermore, logic dictates that the magnitude of the impacts might fairly depend on the project's characteristics, such as quality of survey design and implementation, cognitive level of respondents, the attitude of respondents towards the project, and even the location. As a matter of fact, we might not be even aware some covariates are related to the size of the effect regardless.

Thus, the random-effects model (as oppose to fixed-effect model as shown above) proposed by DerSimonian and Laird (1986), which includes an additional between-studies variance component in addition to the within-study variance component to capture the true treatment effect associated with each specific project, fits this scenario much more precisely (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Lipsey, M.W. & Wilson, D.B., 2001; Card, N.A., 2012). Thus, two components of the variances of mean effect sizes were estimated in this random effect model. They are the within-study variance v_{ij} component as shown in equation (4) which is caused by sampling deviation and between-studies variance ${\tau_i}^2$ component which estimates the population variability and reflects the true differences of effect sizes underlying different projects settings. An estimate of the between-projects variance component (τ_i^2) can be derived from the statistic Q (DerSimonian and Laird, 1986). This estimate was employed in this study and the between-projects variance (${\tau_i}^2$) was calculated by

$$\tau_i^2 = \frac{Q_i - (k-1)}{D_i} \tag{3.8}$$

$$Q_i = \sum_{j=1}^{k} w_{ij}\left[\ln(RR_{ij})\right]^2 - \frac{\left[\sum_{j=1}^{k} w_{ij}\ln\left(RR_{ij}\right)\right]^2}{\sum_{j=1}^{k} w_{ij}} \tag{3.9}$$

$$D_i = \sum_{j=1}^{k} w_{ij} - \frac{\sum_{j=1}^{k} {w_{ij}}^2}{\sum_{j=1}^{k} w_{ij}} \tag{3.10}$$

where k is the number of projects.

Q_i is a statistic that describes the summation of observed weighted square of the deviation of each effect size from the mean. In another word, it represents the amount of heterogeneity in effect sizes among studies in meta-analysis (Cochran, W.G., 1954; Lipsey, M.W. & Wilson, D.B., 2001). A homogeneity test (at significance level of 0.05) of the null hypothesis that the between-projects variance component is zero, is used to test the statistical significance of this second variance component. That is, a test of

$$H_0: \tau_i^2 = 0$$

is based on the Q statistic used in computing the variance component estimate. The test procedure consists of rejecting the null hypothesis whenever Q exceeds the 95% point of the chi-squared distribution with k - 1 degrees of freedom.

Although homogeneity test provided us information about the livelihood of effect sizes being homogeneous versus heterogeneous, it did not inform the magnitude of heterogeneity if it exists. One useful index of heterogeneity in meta-analysis is the I^2 (Higgins, J.P.T., Thompson, S.G., 2002; Huedo-Medina, T.B., Sánchez-Meca, J., Marín-Martínez, F., Botella, J. 2006), which is interpreted conceptually as the percentage of variability among effect sizes that exists between studies relative to the total variability (between and within studies). But as the nature of meta-analysis across studies, the within-study variance varies from study to study (v_{ij} has two subscripts), so there is no single variance (V_{within}) representing all within-study variances. Thus, I^2 index was approximated by a function of Q and k according to its conceptual definition (Higgins, J.P.T., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003) as,

$$I_i^2 = \frac{\tau_i^2}{\tau_i^2 + V_{within}} \approx \begin{cases} \frac{Q_i - (k-1)}{Q_i} * 100\% & when\ Q > k-1 \\ 0 & when\ Q \leq k-1 \end{cases} \tag{3.11}$$

I_i^2 is therefore a readily interpretable index of the magnitude of heterogeneity for each effect size among studies, and it is also useful in comparing heterogeneity across different meta-analyses.

Having incorporated both within and between study variability in the random-effect model as we calculated both values of v_{ij} and τ_i^2, we were able to compute the total variance of each effect size for individual project using equation (3.12). Thereafter, the weight assigned to each study under random-effect model was re-calculated by equation (3.13).

$$V_{ij} = v_{ij} + \tau_i^2 \tag{3.12}$$

$$W_{ij} = \frac{1}{V_{ij}} \tag{3.13}$$

Finally, the weighted mean effect size for each indicator across all projects under the random-effect model was calculated in equation (3.14). Its variance, standard error, and confidence interval were also calculated afterward from (3.15) to (3.18). Because the integration of the between-studies variability, the weighted effect sizes, and their confidence intervals were estimated much more accurately (Higgins, J.P.T., Thompson, S.G., Spiegelhalter, D.J., 2009; Graham, P.L & Moran J.L., 2012).

$$\overline{\overline{\ln(RR_i)}} = \frac{\sum_{j=1}^{k} W_{ij} \ln(RR_{ij})}{\sum_{j=1}^{k} W_{ij}} \tag{3.14}$$

$$V_{\overline{\overline{\ln(RR_i)}}} = \frac{1}{\sum_{j=1}^{k} W_{ij}} \tag{3.15}$$

Instead of deriving standard error of mean effect sizes for each indicator by simply taking the square root of its variance ($V_{\overline{\overline{\ln(RR_i)}}}$), Hedges and others (1999) proposed a more accurate estimate of the standard error of the weighted mean of log response ratio for small sample bias correction as

$$SE_{\overline{\overline{\ln(RR_i)}}} = \sqrt{\frac{1}{\sum_{j=1}^{k} W_{ij}}\left\{1 + 4\sum_{l=1}^{k}\frac{1}{df_l}\left(\frac{W_l}{w_l}\right)^2 \frac{W_l\left[\left(\sum_{j=1}^{k} W_j\right) - W_l\right]}{\left(\sum_{j=1}^{k} W_j\right)^2}\right\}} \tag{3.16}$$

$$LB_{\overline{\overline{\ln(RR_i)}}} = \overline{\overline{\ln(RR_i)}} - 1.96 * SE_{\overline{\overline{\ln(RR_i)}}} \tag{3.17}$$

$$UB_{\overline{\overline{\ln(RR_i)}}} = \overline{\overline{\ln(RR_i)}} + 1.96 * SE_{\overline{\overline{\ln(RR_i)}}} \tag{3.18}$$

where df_l is the number of degrees of freedom in the lth study.

Furthermore, projects were categorized by the length of CBFM and conducted separate categorical analyses (subgroup meta-analyses) between them. The weighted effect size of each indicator in each group was calculated using the same equation (3.14) and treated as an effect size of single study, then the heterogeneity of effect sizes of these ‘studies’ was tested using the same equation (3.9), and the statistic was re-subscripted as Q_{btw} for distinguishing propose. The significance of both Q_i and Q_{btw} were tested against the χ^2 distribution with $k-1$, $g-1$ degrees of freedom (g is the number of group), respectively. All meta-analyses were conducted using random-effects model in Comprehensive Meta-Analysis (CMA) version V3.3 (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009).

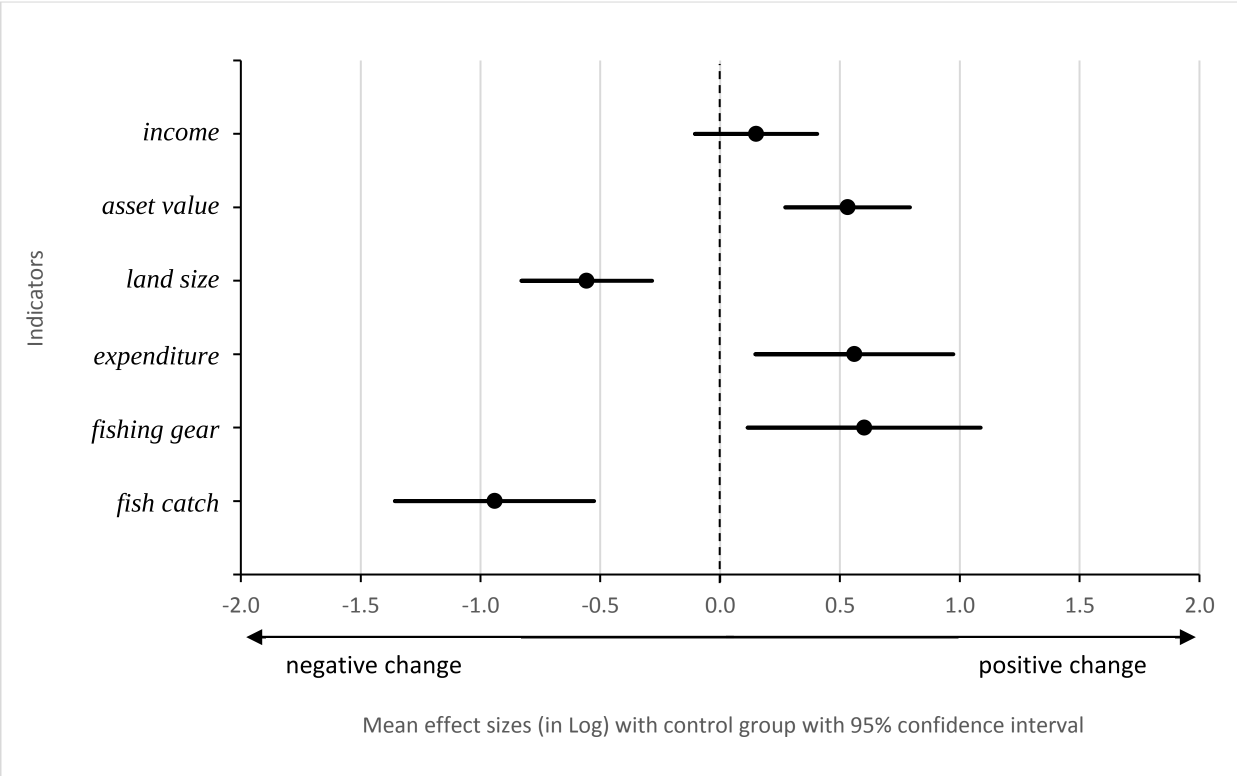
3.4 Results

By extracting the mean of the common indicators in all five projects, six summary effect sizes (*land size*, *fish catch*, *income*, *asset value*, *household expenditure*, *fishing gear*) of CBFM based on six indicators were calculated in the form of response ratio. Rather than focusing on the p-value of each study, it is critical shifting to effect size when the summary effect from multiple studies is what researchers are looking for (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Card, N.A., 2012). However, having summary effect sizes across all five projects calculated, the inconsistency of the effect sizes was also noticed, which indicated that there were some true effect differences (population variability) between projects other than difference caused by sampling deviation. Thus, a categorical analysis was carried out for further seeking how the true effect differences impact each effect size.

3.4.1 Effect sizes

The summary effect sizes of CBFM projects in Cambodia calculated from five individual studies were telling different stories. *Land size* ($\overline{\overline{RR}} = 0.57, CI = 0.44 - 0.75$, p-value< 0.001) and *fish catch* ($\overline{\overline{RR}} = 0.39, CI = 0.26 - 0.59$, p-value< 0.001) were perceived to decrease statistically significant through the CBFM. *Income* ($\overline{\overline{RR}} = 1.16, CI = 0.90 - 1.50$, p-value$= 0.250$) was perceived to increase over time, but was not statistically significant. On the other side, *asset value* ($\overline{\overline{RR}} = 1.70, CI = 1.31 - 2.21$, p-value< 0.001), *household expenditure* ($\overline{\overline{RR}} = 1.75, CI = 1.16 - 2.65$, p-value$= 0.008$), and *fishing gear* ($\overline{\overline{RR}} = 1.82, CI = 1.12 - 2.97$, p-value$= 0.015$) were all perceived to increase statistically significant during the same time period.

Figure 1. Summary Effect Sizes (In Log) Of CBFM Projects in Cambodia Based on Six Indicators.



3.4.2 Heterogeneity Analysis and Categorical Meta-Analyses

The effect sizes of all six indicators were discovered to be inconsistent across studies after applying the homogeneity test (Q-stat. in Table 4), which indicated that there were some true differences (population variability) in effect size across projects and those variations were not fading out if sample size has dramatically increased. The heterogeneity of each effect sizes across projects was also revealed by I^2 statistic, which represents the proportion of the observed variance reflecting real differences in effect size (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Higgins, J.P.T., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003).

To further reveal the heterogeneity of effect sizes which was indicated by both significant statistical Q statistic and the large percentage of I^2 derived from the overall meta-analysis, all project studies were then categorized according to the duration of CBFM projects (project 1,2 and 5 were longer than five years, project 3 and 4 were less than five years) and conducted separate meta-analyses (Figure 2) and categorical meta-analyses (Table 4) between them.

The effect sizes of CBFM were discovered quite differently in two groups that categorized by the duration (five years) of CBFM. For the group with less than five years of CBFM, *income*, *asset value*, *household expenditure*, and *fishing gear* were showing positive effect sizes (weighted), while *land size* and *fish catch* were showing negative effect sizes (weighted). For the other group with more than five years of CBFM, *income*, *asset value*, *household expenditure* and *fishing gear* were showing bigger positive effect sizes (weighted) (all effect sizes were statistically significant except for *income*). While the *land size* and *fish catch* were showing negative effect sizes (weighted) (both were statistically significant). Furthermore, the difference in effect size of each indicator between two groups was tested, and the results showed the statistically significant differences in effect sizes of *asset value* (Q_{btw}=13.54, p <0.01) *household expenditure* (Q_{btw}=7.25, p <0.01), and *fish catch* (Q_{btw}=8.77, p <0.01). As for other effect sizes (weighted), although they were not showing significant changes (Table 4), the difference between two groups of their true effect can also be estimated by their confidence intervals, which fall in the range of -1.024 to 1.495 (*income*), -1.664 to 1.241 (*land size*), and -2.130 to 3.689 (*fishing gear*) as showing in Table 4.

Table 4. Homogeneity Test of Effect Sizes and Categorical Analysis in Cambodia.

	Overall meta-analysis			Categorical analysis (between two groups)			
Indicators	$Q-$ stat.	P-value	I^2 $-$stat	$Q_{btw}-$ stat.	P-value	Std. Error	Confidence Interval
income	14.391	0.006	72.21	0.624	0.430	0.643	-1.024, 1.495
asset value	14.455	0.006	72.33	13.540	0.000	0.376	0.106, 1.581
land size	15.739	0.003	74.59	1.364	0.243	0.741	-1.664, 1.241
expenditure	36.751	0.000	89.12	7.254	0.007	0.599	-0.060, 2.289
fishing gear	50.180	0.000	92.03	0.531	0.466	1.484	-2.130, 3.689
fish catch	34.583	0.000	88.43	8.768	0.003	0.692	-1.723, 0.990

Figure 2a. Effect Sizes (In Log) With Less Than Five Years of CBFM in Cambodia.

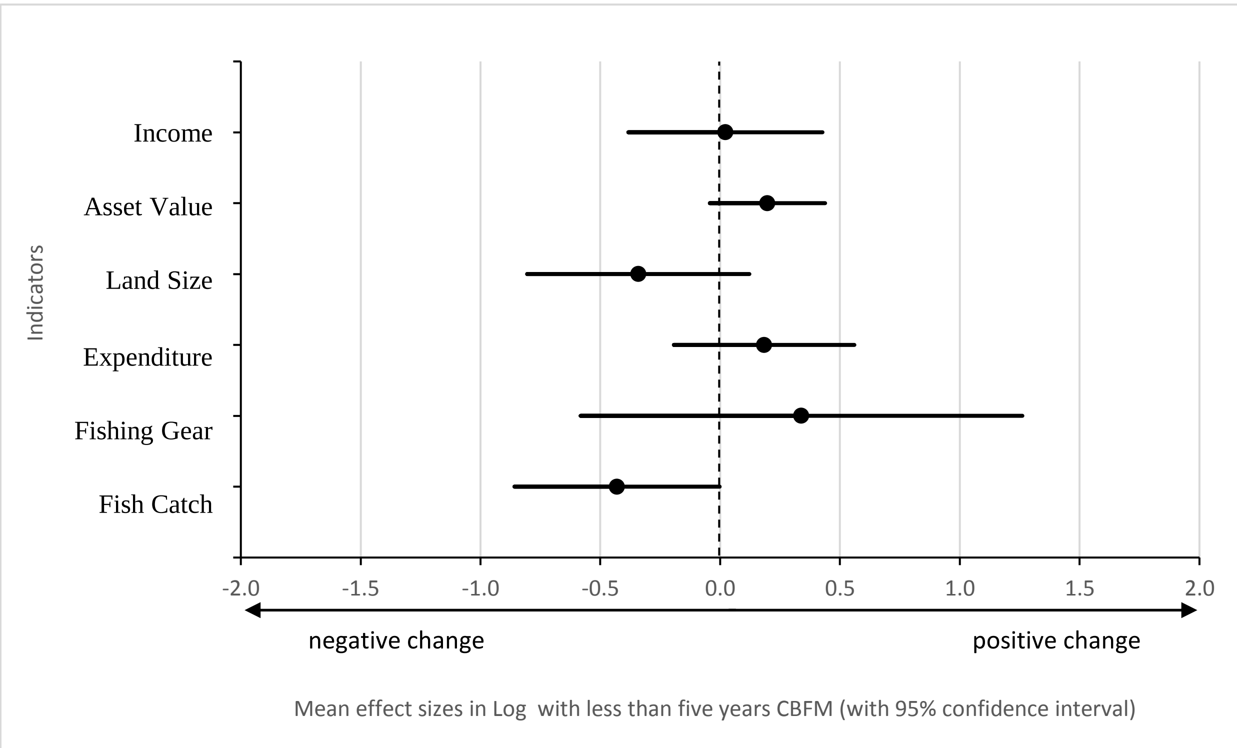
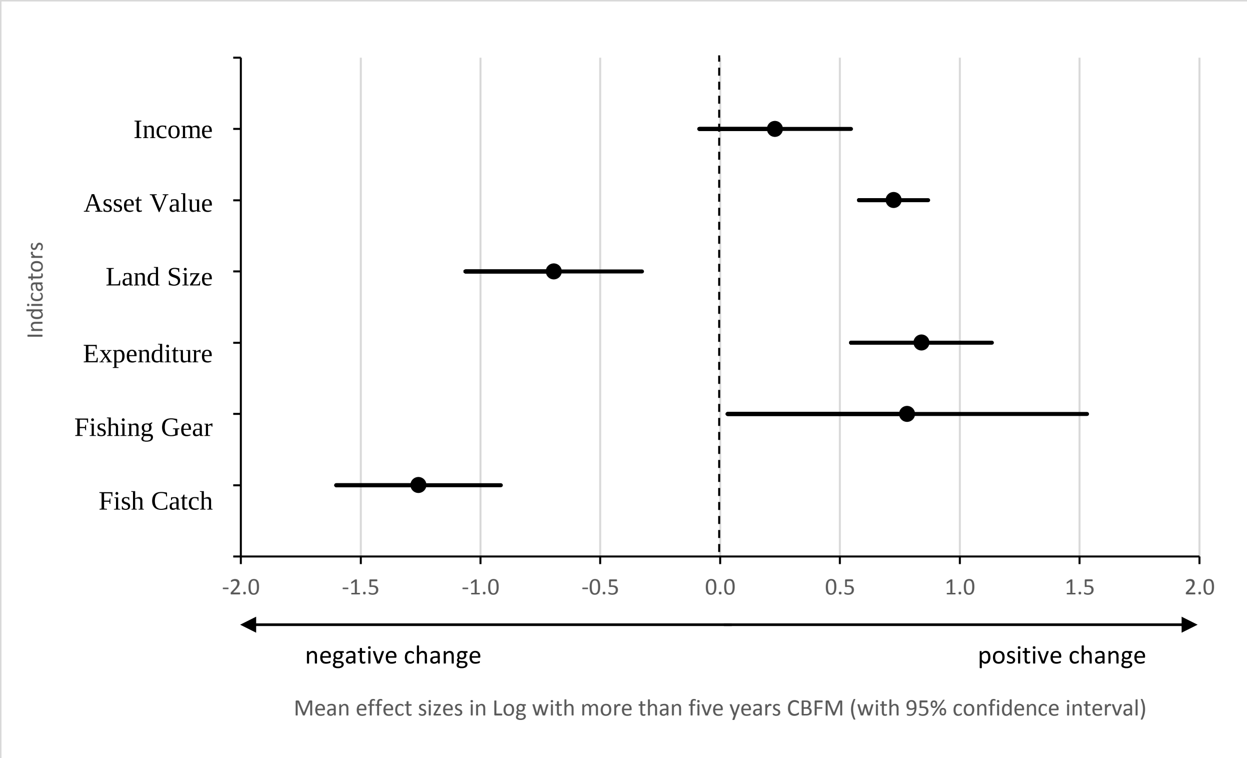


Figure 2b. Effect Sizes (In Log) With More Than Five Years of CBFM In Cambodia.



3.5 Discussion

Overall, the summary effect sizes of CBFM for the selected projects in Cambodia were discussed in the first part of this section, which could be considered as positive for *income*, *assets value*, *household expenditure*, and *fishing gear*, while negative for *fish catch* and *land size*. Also, the difference between the impact assessment through effect sizes calculation with and without the control group was also quantified and discussed in the second part of this section.

3.5.1 Effect sizes

Income

The summary effect size of selected CBFM projects in Cambodia for *income* was small but positive ($\overline{\overline{RR}} = 1.16, CI = 0.90 - 1.50$). It indicated that small-scale fishers have better income with the participation of CBFM projects than those without. The World Food Program reported that personal disposable income has increased as agricultural commodities sell for higher prices since 2005 in Cambodia (El-Noush, 2010). Combining with more organzied community, fishers have better access to the market information and therefore less transaction cost and higher profit (Seng, K., Song, S.L., Navy, H., Leang, S., 2005). Community-based management systems and associated fisheries rights and tenure arrangements have been shown to provide an efficient and equitable system for extracting and distributing resource rents (Pomeroy, R.S., 1995). In addition, the income improvement of fishers in CBFM was also reported in other studies (Islam, G.M.N., Dickson, M.W., 2006; Thompson, P.M., Sultana, P., Islam, G.M.N., 2003; Thong, H.X., Noi, H., 2010; Vann, 2005). Although the effect size of *income* did not show statistical significance in this study, it was still a very meaningful result. Considering the confidence interval (0.90, 1.50) of its effect size, where there was 83% of confidence intervals that greater than one, it did reveal a positive effect of CBFM on the fishers' income for the selected project with high probability. In addition, the existence of vastly diverse income sources in small-scale fishers, especially for the community-based fisheries village with more information exchange and the inability to fully account for all these income sources in the individual project survey also lowered the statistical power of its summary effect size. In Cambodia, rice and fish production have been considered as the major food sources as well as employment. Although two separate sub-sectors in agriculture in Cambodia, they are tightly bound by the unique floodplain ecosystem, particularly in the Tonle Sap Lake where nearly 90 percent of the local households have the joint occupation of fishing and farming as their main occupation for livelihood (ADB, 2010; FiA, 2009; Navy and Bhattarai, 2006; Rab, M.A., Navy, H., Ahmed, M., Seng, K., Viner, K., 2006).

Asset Value

The summary effect size of *asset value* for the selected CBFM projects was positive ($\overline{\overline{RR}} = 1.70, CI = 1.31 - 2.21$). With increased income as mentioned above, fishers have surplus for investment in various assets. There were four main capital assets based on the finding from selected projects (house, boat, housing appliances, and electronic appliances). The house contributed to a high proportion of household asset and, the cost was greatly varied by location. More importantly, with more people having noticed the income increase for the CBFM participants, the boat has increased in value over time. Housing appliance and electronic appliances are also important assets for the fishing community, and have direct impact upon standard of living for the fishing household. With their relatively inexpensive price comparing to the fixed assets, increased income would have bigger impact on the increase in these assets for fishing households. This positive effect on asset was verified in the categorical analysis which returned the statistically significant results indicating that the effect size of *asset value* over a longer period of CBFM was larger than the one in a shorter period of CBFM.

As a very crucial indicator for assessing the quality of a livelihood, *asset value* was mentioned as a necessary component in the definition of many livelihood projects worldwide (DIFD, 2000; Dorward, A., Kydd, J., 2003). Almost all descriptions about livelihood emphasize the equal importance of both income and ownership of assets

(Macauslan, I., Phelps, L., 2012). The Sustainable Livelihood Approach (SLA), introduced by DIFD, even specified five types of assets which could be fundamental for livelihood improvement (DFID, 1999). Also, it has been recognized in CBFM that the ownership of assets plays a unique and crucial role in alleviating and buffering stress, shock, vulnerability, and risk from both socioeconomic and natural disturbance (Zalinge, N.V., Thuok, N., Tana, T.S., 1998). This positive impact made the fishing community members feel more secure and developed a strong basis for assets accumulation (Marschke, M., 2003; Marschke, M., Nong, K., 2003; Rivera-Guieb, Rebecca, Graham, J., Marschke, M., Newkirk, G.G., 2004).

Household Expenditure

The summary effect size of CBFM on *household expenditure* was positive and sizeable ($\overline{\overline{RR}} = 1.75, CI = 1.16 - 2.65$). It should be no surprise that increased in household expenditure was expected given the increased income and investments as we discovered before. Comparing with income, household expenditure is less prone to error, easier to recall and more stable over time, therefore can be used as a proxy of the true household income (Moore, J.C., Stinson, L.L., Welniak, E.J., 2002; Vuthy, T., Socheat, K., Pirom, K., Chhun, C., Dary, P., 2013). There were four major expenditures for the fisheries household reported in the selected projects, food (mostly rice paddy purchase), health (medicines), fishing gears, and social expenditures (wedding, funerals, Khmer New Year, Pchum Ben Day). The Standard of Living Assessment in Cambodia (National Institution of Statistics, 2007) and The Poverty Profile and Trend by World Bank (Knowles, J.C., 2009) both indicated that more organized fishing villages reported more health expenditures as the availability of clinic and medicine. In addition, more organized fishing community entails more regulatory fishing practice and therefore stable fishing related expenditure (El-Noush, H., 2010).

Fishing Gear

The summary effect size of CBFM on the *fishing gear* was large and positive ($\overline{\overline{RR}} = 1.82, CI = 1.12 - 2.97$). With constant, if not decreased, paddy rice production from 2000 to 2005 (National Institution of Statistics, 2009), and increased income of fishers by the expansion of CBFM, more investments were put in the fishing gear which was consistent with the value increased in boat. Because the composition of fishing and farming employment varied considerably by location, the shift of investment to fishing also varied. Also, the fishing-only communities would contribute less to the effect size on *fishing gear* simply due to the limited room for investment accumulation in fishing gear compared to the farming or farming and, fishing communities would do. This general investment transition and its variation explains the positive effect size (statistically significant) on *fishing gear* and its wide confidence interval.

Like the effect size of *Asset Value*, the positive summary effect size of *fishing gear* mainly attributed to the solid basis of managing the resource by establishment of a stable tenure in CBFM, which makes fishers capable of managing resources with a long-term plan and without fear of reprisals from fishing lot owners and policy diversion (Kurien, J., So, N., Mao, S.O., 2006). In addition, more stable ownership in the CBFM provided more incentives for fishers to further invest in their production. This also links with the results from the categorical analysis, where the group with longer duration of CBFM had a larger mean effect size.

Land Size

The summary effect size of CBFM on *land size* was less than one for the selected projects ($\overline{\overline{RR}} = 0.57, CI = 0.44 - 0.75$). The land is not only valuable in price, but also in its capacity for income diversification for the rural household, especially the opportunity for diversified agricultural activities. As mentioned in *asset value*, the employment composition around Tonle Sap Lake was mainly fishing and farming. But with the reconstruction of the country after constant war and subsequent drastic population growth, as well as uncontrolled land concentration, the competition for land has grown ever more intense (Billon, P.L., 2001; Cock, A., 2010; Marschke, M., Nong, K., 2003; Un, K., So, S., 2009).

Rapid economic growth caused land in rural areas to increase in value and become a target for both domestic and foreign investors since the 1990s. However, as more than 80 percent of the Cambodian population lives in rural areas where the customary law still predominantly prevails, the government failed to properly introduce the modern legal system of private ownership in those parts of the country. It became crucial for those holding land under customary law to gain legal title to it to prevent losing it. Unfortunately, out of 173 land disputes reported in 2008, with the average number of affected households in dispute was 188 families, and the average size of the disputed area is 276 hectares, only two percent of the disputants had official documents to prove ownership. (NGO Forum on Cambodia, 2009; Sekiguchi, M., Hatusukano, N., 2013)

Land ownership in Cambodia has experienced several transitions in form after its independence from France in 1953. After several ownership reforms along with regime changes, the ownership of residential land and cultivated land were not fully recognized until 1992 (Pel, S., Yonekura, Y., So, S., Saito, K., 2005). Cambodia Development Resource Institute (CDRI) reported that land distribution in Cambodia was highly skewed, and the minority (20% to 30% of total population) who are rich and well-off owned the majority of land (70%), while the large majority of the poor and worse-off people had only small portion of land (10%) to live on (Boreak, S., 2000). Conflicts over land have increased in Cambodia because of the ambiguity of land rights. The land grabbing was pervasive and was dominated by people with more power than their victims who were most fishers (Williams, S., 1999). According to the Protracted Emergency Target Survey in 1998, over 5 percent of the interviewed households reported a forced takeover of agricultural land. With this confused land ownership and capital intensive nature of agriculture activity, fishers in the CBFM would rather like to trade their land for more stable financial assets before the land was enforceable sold or coercive taken because the fishing activity under CBFM was perceived as a more secure employment and therefore sustainable livelihood by the fishers.

Fish Catch

The effect size of Fish Catch ($\overline{\overline{RR}} = 0.39, PI = 0.26 - 0.59$) was less than one, which seemingly indicated a negative impact of community-based fisheries management. It's worth remembering the fact that the Tonle Sap Lake has been overfished for a long period during the large-scale fishing lot management which caused complete change of fish composition, the recovery of actual useable fish is by no means fast (Pauly et al., 1998). However, despite that effect size of Fish Catch showed a somehow discouraging trend from the overall meta-analyses, the results revealed the improvement of fish catch by applying the community-based fisheries management with more specific context.

In the categorical meta-analysis, the way of grouping the study was according to the duration of community-based fisheries management. The projects with shorter duration all started in 2000, which happens to be the year of the expansion of community-based fisheries by the Cambodian fishery reform. Two groups were identified as those before the expansion of CBFM and those after it. Considering the mobility of fish in the Tonle Sap Lake, having more areas organized by community-based fisheries management instead of traditional fishing lots management provided more consistent and accurate measure of the effect size of community-based fisheries management on fish catch.

Thus, the results derived from categorical analyses made more sense regarding fish catch. Because the group ($\overline{\overline{\overline{RR}}} = 0.65, PI = 0.42 - 0.99$) with projects started after the reform (year of 2000), they presented a bigger effect size than the other group ($\overline{\overline{\overline{RR}}} = 0.28, PI = 0.20 - 0.40$). More meaningfully, the two results were statistically different. Although both were less than one, which means the two groups were all showing a negative effect on fish catch, the significantly different effect sizes in the two groups indicated that projects started after the expansion of community-based fisheries showed improvement (larger effect size) in the fish catch compared with ones started before the expansion.

The fisheries policy reform had been initiated in 2000 by the Cambodian Prime Minister Hun Sen, which included releasing 56 percent of Cambodia's commercially zoned fishing area for the exclusive use of small-scale fisheries (Evans, 2002; Marschke and Sinclair, 2009; Sneddon and Fox, 2007). Moreover, an announcement was made by the prime minister in 2012 which suspended all remaining commercial fishing lots on the country's most productive freshwater ground, the Tonle Sap Lake. This drastic policy reform led to some significant changes, not only at the institution level but more importantly to the local communities, which sent a strong signal for shifting the focus of fishery to the livelihood-orientated small-scale fishery from the commercial-orientated large-scale fishery.

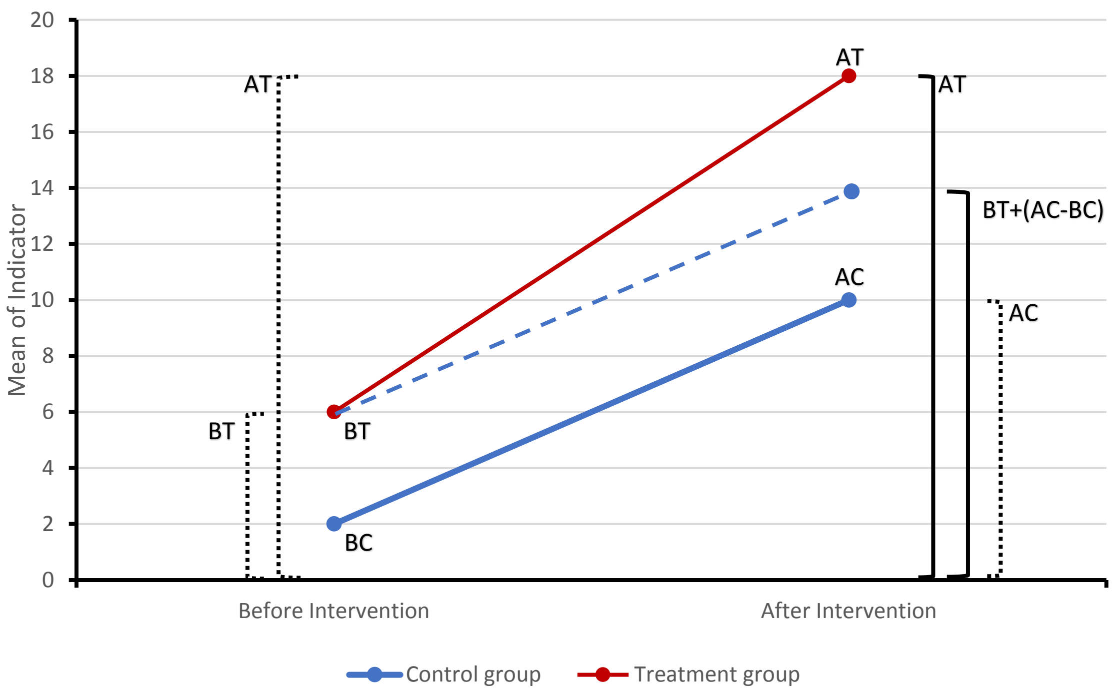
3.5.2 Control group integration

As mentioned in the methodology, the effect size (Response Ratio) using in this meta-analysis was modified with the control group difference integration. It is noted that the most of the fisheries project reports or project assessment studies in the Southeast Asia did not utilize the information of control group difference (CRMP, 2004; FISH, 2010; Mustafa, M.G., Halls, A.S., 2007). For some that did, which are either a paired-comparison (difference or ratio) of indicators between control group and treatment group both after the project (AT and AC), or for the most case, a paired-comparison of indicators between before and after the project only in treatment group (AT and BT) as shown in Figure 3. Neither would be the accurate or proper outline of the project assessment because they are unable to control the factors that would have an impact on the targeting indicators but are not associate with projects interventions.

For the measure of Response Ratio in Figure 3, the ratio of AT over BT is used for effect size construction based on one indicator if the control group is not integrated. As shown in the specific case in Figure 3, this measurement ($\frac{AT}{BT}$) contains a big portion of increase (AC-

BC) that will be presented even there is no treatment at all. Thus, to limiting the overestimate in this case, the Response Ratio was constructed as $\frac{AT}{BT+(AC-BC)}$ for a more accurate assessment. This modified response ratio also applied to the case where the natural trend is downward.

Figure 3. Effect Size Comparison in Project Assessments in Cambodia.



After calculated the summary (weighted) mean effect sizes for all six indicators without control group integration, they were compared to ones that with control group integration which was used in this study, both were showed in the table below.

Table 5. Comparison of Weighted Effect Size Between w/ and w/o Control Groups.

	w/ control group		w/o control group	
	Weighted Mean	CI	Weighted Mean	CI

Income	1.161	(0.900, 1.499)	1.420**	(1.004, 2.007)
asset value	1.703***	(1.313, 2.209)	2.515***	(1.621, 3.902)
land size	0.573***	(0.436, 0.753)	0.584***	(0.470, 0.725)
expenditure	1.751***	(1.158, 2.646)	2.179**	(1.285, 3.695)
fishing gear	1.824**	(1.122, 2.966)	1.853**	(1.146, 2.995)
fish catch	0.390***	(0.258, 0.591)	0.277***	(0.154, 0.500)

Statistical significance is noted by two asterisks (**) at the 5% level, and three asterisks (***) at the 1% level.

In the measure of original response ratio, the impact of CBFM might be easily concluded as 42%, 152%, 118%, 85% increase in *income*, *asset value*, *expenditure*, *fishing gear*, and 42% and 73% decrease in *land size* and *fish catch*, respectively. However, interpretation of response ratio using the value of each indicator before and after (only in the treatment group) as the effect of the CBFM could lead to significant error and therefore faulty judgment. By incorporation of control group difference in the effect size (response ratio), we can partition more accurately about the pure effects that the CBFM brings upon on the fisheries resource and fishers' livelihood rather than the total effects (pure effect and natural trend) that were observed during the CBFM projects.

Through the comparison of effect sizes calculation between two measures of effect sizes, nearly all effect sizes of indicators were overestimated by 1.6% (*fishing gear*) to 47.7% (*asset value*) under the assessment of selected projects in Cambodia without control groups integration. The effect size of income was showing a 42 percent increase through the CBFM in the effect size measure without control group difference integration, which turned out to be 22.3% overestimate comparing to the effect size measure with control group difference. More importantly, the effect size in former measure was showing statistical significance while the latter was not, which would make this overestimation has bigger impact on the project assessment and subsequent decision making. This comparison of different measure of effect sizes indicated that the impact of CBFM on fishers' livelihood were overestimated by a sizeable margin when control group difference was not integrated in the modelling of effect sizes measure. However, the *fish catch* was the indicator with the underestimated effect size (29%) comparing to another measure of effect, which, by the setting of control group integration, indicated that the *fish catch* was experienced a more dramatic decline in the control group than the treatment group with CBFM. This is likely due to all levels of community collaboration such as knowledge sharing in both catch and storage process, considerable effective monitoring and enforcing, more accurate data acquiring, and much less competitive than non-organized fishers.

3.6 Conclusions

The overall outcomes of meta-analyses in this study indicate a mixed view of how the effects of CBFM on the livelihood of fishing communities and sustainable management of fisheries resources in Cambodia by investigating six indicators. The positive summary effect size of *income, household expenditure, asset value,* and *fishing gear* conjunctly portrayed an improved livelihood of the fishing community with 16%, 75%, 70%, 82% increase in their mean by implementing CBFM. The negative (less than one) effect size of *land size* (57% decrease in mean) revealed the difficulties in improving social inequality and the ownership confusion caused by the introduction of a modern legal system by the government and the customary law that prevails in most rural areas. The effect size of *fish catch* by implementing CBFM, although still negative (61% decrease in mean), revealed a small but statistically significant improvement (37% increase in mean) in longer projects through categorical analysis. Further, by comparison the weighted effect sizes with control group and without control group integration, a pattern of overestimation in livelihood indicator and underestimation of fisheries resource indicator was discovered. The difference in weighted mean effect sizes between two measures ranged from -29% to 47.7%, plus the critical difference in effect size of *income*, which would highly bias the project assessment for both the project donor and local development authority and perception of status of fishers' livelihood and fisheries resources. Both two biases would certain affect the decision making of future policy in this sector.

By providing and protecting the rights to manage their fisheries, the Royal Government of Cambodia (RGC) introduced CBFM to local people to manage and exploit these resources themselves in a manner of sustainable fisheries management. It provides fishers an unprecedented incentive to support and participate in fisheries management by clarifying and securing the fishing tenure. With the continuous promotion by the Cambodia Government, 468 CBFM sites had been established by 2010, compared to only a handful of CBFM existing in the 1990s (Marschke, 2012). Also, 77 percent of all abolished fishing lots (3,197 km^2) were designated exclusively for community-based fisheries by the end of 2012 (Sovannara, H., 2014). Furthermore, the Strategic Planning Framework for Fisheries 2010-2019 has been finalized to facilitate law enforcement on CBFM (FiA, 2012). Overall, the government of Cambodia has made significant progress in supporting fisheries management through the community-based approach, which includes formulation of policies and regulatory framework, institution setting, human resource development, capacity building, as well as the implementation of alternative livelihood programs (Baran, E., Gallego, J., 2015; Matschullat, J., Freiberg, B., 2014).

Nevertheless, some issues that could potentially hamper the sustainable fisheries management and the consequent livelihood of fishing communities were also discovered. Community-based management systems and associated fisheries rights and tenure arrangements have been shown to provide an efficient and equitable system for extracting and distributing resource rents (Pomeroy, R.S., 1995). However, the negative effect size of *fish catch* still reminding the fact that the fisheries resource has been overfished for a long time, and the stock recovery is by no means an easy process. The livelihood improvement of the fishing community achieved by CBFM was mainly dependent on participatory planning, enhanced compliance, and elimination of illegal fishing activities. Thus, CBFM would be more effective if it couples with some stock recovery programs (i.e. fish sanctuary) (Chum, N., Baran, E., Chervier, C., Leng, S.V., Emmett, D., 2010), for targeting on direct fish stock enhancement in Tonle Sap lake, which CBFM was not majorly targeted. Although it is very important and necessary to organize the fishers to practice fishing in a sustainable manner, limit the expansion of fishers is the key to addressing overcapacity given the already severely over-exploited fish stock in Cambodia. Thus, access control is inevitable for sustaining fisheries resource, but the way of establishing access is even more critical. As the "last resort" of livelihood and the function of social safety net, access to small-scale fisheries cannot be established solely by blocking, it is important to be done along with establishment of alternative livelihoods for channeling the labor out of fisheries, which is only feasible based on a well-organized fishing community.

Also, , the negative effect size of *land size* in this study revealed the significant loss of land owned by the fishing households. The land loss may not be a direct threat to the fishing community. However, given the already deep dependency on fisheries resource for those communities, losing an important alternative source of livelihood could severely impact on the household. Also, for the fisheries resource, overcapacity is the urgent issue as mentioned before and could be only tackled from the perspective of lowering the dependency on fisheries resources and channeling the labor out of fisheries. Thus, in the long term, losing land will drastically increase the vulnerability of the fishing communities and exert more pressure on fisheries resources. Local authorities and the government of Cambodia have to be clear about this inter-sectoral relationship. Moreover, the coexistence of multiple land ownership systems and the marginalized social status of fishing household further contribute to the vulnerability of fishing community regarding highly dependency on fisheries resource and deficiency of alternative income generation mechanism. Due to the attempt to reform the legal system by the Government of Cambodia, there has been little chance to incorporate the traditional legal concepts rooted in local society with more modern concepts of land ownership. This transition has resulted in a quilt of overlapping laws with some reaching back centuries, some recent, customary law, the French Civil Code, socialism, and private ownership under the modern law (Sekiguchi, M., Hatusukano, N., 2013). In addition, as the most vulnerable and powerless social group, the land owner in fishing communities or the rural region in Cambodia in general, who still claim their ownership based on customary practice, are most likely to be displaced from their land due to the inconsistent legal system. In Cambodia, nearly 90 percent of the local households have the joint occupation of fishing and farming (Navy, H., Bhattarai, M., 2006). Thus, suitable rules and regulations have to be drawn up as soon as possible in order to acknowledge and protect different land ownership first, then issue a uniform system to gradually replace the old ones.

There are some other issues that do not only reside in the aspects of institutional (Baran, E., Samadee, S., Shwu Jiau, T., Thanh Cong, T., 2011; So, N., Haing, L., 2007), but also in the socio-economic aspect of resource users, such as limited knowledge, understanding, and skill to undertake both planning and implementation of CBFM (Deepananda, K.H.M.A., Amarasinghe, U.S., Jayasinghe-Mudalige, U.K., 2015). This can also have a considerable impact on both fisheries resource and the livelihood of its users (Sultana, P., Thompson, P.M., 2007). Thus, having more studies with questions about attitudes and perceptions would significantly enhance the comprehensiveness and accuracy when performing an assessment of community-based fisheries management. This study was not an exhausted performance evaluation due to the limited indicators and project availability, but it does shed some light on the relationship between resources and people's dependency on it, It also attempted to evaluate the performance of CBFM for small-scale fisheries. This study also provided a first attempt to apply meta-analysis of effect size, using random-effects model, in the context of the resource management and rural development in Cambodia, which is relevant to improving the quality of livelihood among poor rural people, as well as alleviation of poverty. Also, the incorporation of control group difference resulted in a more accurate assessment of CBFM by limiting the factors that have impacts on the targeting indicators but was not associate with CBFM interventions. Overall, comparing to narrative synthesis, which suffers from the subjectivity of drawing a conclusion from various studies, meta-analysis is capable of statistically synthesizing the data to discover the direction and magnitude of the overall effect, in a transparent, objective, and replicable manner through weighting each qualified study (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009). Moreover, the results of this study could be used as information for institutions who want to apply community-based fisheries for rural development, especially the Royal Government of Cambodia (RGC), the Fisheries Administration, and donor agencies.

CHAPTER IV

THE IMPACT OF COMMUNITY-BASED FISHERIES MANAGEMENT (CBFM) ON SMALL-SCALE FISHERIES IN DIFFERENT INLAND WATERBODIES IN BANGLADESH

4.1 Introduction

Bangladesh is a small riverine country, with a total land area of 147,570 square kilometers. However, it hosts the one of the largest deltas, Ganges-Meghna-Brahmaputra (GMB) delta, in the world with the total area of 105,641 square kilometers (72% of total land area). With accommodating 130 million (82% of national population) people in this region, the GMB Delta belongs to the most densely populated areas in the world (1,600 pop. /km^2) (Barbosa, C.C., Dearing, J.A., Szabo, S. and Matthews, Z., 2016). During the rainy season, over one-third of the land area of Bangladesh are usually inundated, and more than half of the country (68%) was under water in the exceptional flood year of 1998 (Feeroz, M.M., 2013). More than 40,000 square kilometers of inland waterbodies and floodplains make Bangladesh the world's richest while most complex fisheries (Sultana, P. and Thompson, P.M., 2007). More than 260 fish species are bred in flowing rivers, *beels* (floodplain depressions with perennial water), oxbow lakes (large deeply flooded depressions), and floodplains, and over 400 fish species are found in the coastal water (Feeroz, M.M., 2013; Foster-Turley, P., Das, R., Hansan, M.K. and Hossain, P.R., 2016).

Because its unique geographic characteristics, about 70% of rural households rely on fisheries as the major source of food and income (Thompson, P.M. and Hossain, M.M., 1998). However, nearly half of the population (45%) have an average energy intake of less than 2,122 kcal per capita per day (Haughton, J. and Khandker, S.R., 2009), given the daily energy requirement by WHO (2001) was 2500 kcal per person. Of the animal protein intake, 60 to 80 percent are solely from fish consumption (BBS, 2008; Kawarazuka, N. and Béné, C., 2011; Muir, J.F., 2003). In the meantime, there was 35 to 45 percent of the population who is classified as poor by World Bank standard for poverty (Bank, World, 2015; BBS, 2008; GPRB, 2005). Bangladesh remains one of the poorest countries in its region, with poor public services and institutional capacity to implement a broad suite of policies to ensure the quality of development (Foster-Turley, P., Das, R., Hansan, M.K. and Hossain, P.R., 2016). Combining the threats from both poverty and food insecurity, as an accessible and nutritious food source, fisheries remain the irreplaceable and most fundamental source of food as well as the livelihood of the fishing communities (Thompson, P.M. and Hossain, M.M., 1998). Also, the economic value of fish and other aquatic resources has been found to be more than double the return from a single rice cultivation (Colavito, L., 2002).

The floodplains are rich in nutrients and provided quality habitats for fish and other aquatic living resources (Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. and Kent, J., 2000). However, excessive fishing efforts in fisheries are now a major threat to the livelihood of poor fishers as well as the sustainability of fisheries itself. Several government reports indicated that catch per unit of effort has declined in inland fisheries (DoF, 2006; ICF, 2006). Muir (2003) estimated that the inland capture fisheries production had fallen by 38 percent from 1995 to 2000, and the fish consumption consequently fell by 11 percent during the same period. The high percentage (35% to 45%) of poor population along with their deep dependency on fisheries resources (BBS, 2008; GPRB, 2005) compel fishers and local people to harvest fisheries resources in unsustainable ways. The use of fine-mesh nets catches everything in the waterway, including non-target species and juveniles, reducing reproduction rates for all species. Catching fish by using chemical materials and draining water from the wetlands during winter. All these destructive fishing practices are causing an adverse effect on fish production and ultimately the entire ecosystem. With no monitoring programs in place, there is no data on the extent of these problems but many interviewees talked about them, and examples were seen by the assessment team in the field (Foster-Turley, P., Das, R., Hansan, M.K. and Hossain, P.R., 2016).

In Bangladesh, fisheries management had majorly targeted on revenue generating through the short-term leasing of exploitation rights on different types of public-owned water bodies. The leasing contract was conferred through an open auction and the leases are usually obtained by the rich and influential people who are then able to appropriate maximum share of the benefits from the fisheries by employing the poor with meager wage (Ahmed, M., Capistrano, D. and Hossain, M.M., 1992; Sultana, P. and Thompson, P.M., 2007). The limitations of the natural resource related government agencies include poor institutional capacity, insufficient manpower and lack of logistical and operational support (Foster-Turley, P., Das, R., Hansan, M.K. and Hossain, P.R., 2016). Although Bangladesh has some sound policies regarding biodiversity and environmental protection, there are still many gaps, for instance, wetlands are scantily covered. Also, the Department of Fisheries (DoF) has an acute shortage of field level staff and vessels to oversee the resources or to enforce laws. There is little knowledge of the importance of biodiversity for DoF officials, and they are only trained to handle economic species and to collect license fees. All of which will not only degrade fisheries resource for providing food and employment, they will also weaken the sustainability of every donor-initiated project.

The approach of community-based management on fisheries have been implemented in several countries to promote sustainable use of fisheries and the equitable distribution of benefit (Pomeroy, R. S. and Rivera-Guieb, Rebecca, 2005; Viswanathan, K.K., Nielsen, J.R., Degnbol, P., Ahmed, M., Hara, M. and Nik Mustapha, R.A. , 2003). The Department of Fisheries and several NGOs in Bangladesh jointly initiated a community-based fisheries management (CBFM) project for the inland fisheries in the early 1990s. Two phases were implemented from 1995 to 2007 consecutively, covering 130 waterbodies (3 types), aiming at increase the income of fishing households and restore fish stock through community-based management. Recently empirical studies highlighted that fishers can obtain social, economic and institutional benefits under the CBFM in Bangladesh (Hossain, M., Islam, K. and Andrew, J., 2006; Islam, M.A., Majlis, A.B.K. and Rashid, M.B., 2011; Kabir, K., Saha, N.C., Oliveras, E. and Gazi, R., 2013). However, the studies are not available to (1) identify the magnitude of the impacts and counteract the change in impacts that occur over time, and (2) inspect the heterogeneity of the impacts on different types of water bodies and identify their magnitudes. Thus, this study specifically aims: (1) to estimate the magnitude of impacts of CBFM projects on sustainable fisheries management and fisher' livelihood in Bangladesh, (2) to investigate the heterogeneity and the magnitude of these impacts of CBFM projects on different types of waterbodies.

4.2 Community-Based Fisheries Management (CBFM)

The regulatory framework governing the inland fisheries of Bangladesh today exemplifies policy constraints common to many developing countries. The main issues consist of the needs to address urgent development, sustainable utilization of fishery resource, and weak implementation and monitoring (Muir, J.F., 2003). These issues are further worsened by the world leading population density and inevitably food insecurity in Bangladesh (Gray, D. and Mueller, V., 2012). The scheme of production-orientated or rent-maximizing fisheries management coupling with advanced technologies pay little attention to, if not completely overlook, ecosystem integrity and fisher's livelihood, which are very closely associated.

Community-based fisheries management has drawn considerable attention worldwide because it offers an opportunity to the local resource users to participating in fisheries resource management (Hanna, S., 1995; Jentoft, S., 2005; Nielsen, R.J. and Vedsmand, T., 1999; Pomeroy, R. S., 1994). This approach addresses direct management and development issues of the fisheries, as well as issues outside of the fisheries but of direct consequence to fishers and fishing communities, such as rural economic and community development. Also, one of the benefits of the self-managing approach is higher efficiency and effectiveness in enforcement and monitoring process than bureaucracies do (Dey, M.M. and Kanagaratnam, U., 2007). Moreover, because of the management complement local cultural value, the incentives to respect and support the rules are self-imposed and are individually and mutually beneficial. The purest form of CBFM is a system in which fishers and their communities exercise primary responsibility for stewardship and management, including taking part in decision-making on all aspects of management, such as access, harvest, and monitoring (Weber Michael L. and Iudicello Suzanne, 2005). It defines a type of fisheries management which is created by fishers under their initiatives, and as its characteristics indicate, the resources have been delegated to local resource user to manage in a sustainable manner and contributing to rural poverty alleviation (Yamamoto, T., 1996). Thompson (1999) summarized the six benefits in CBFM as sustainability, economic equity, social equity (both inter and intra-groups), knowledge sharing, and security of tenure on resources.

After several management scheme changes, the approach of community-based management for the inland fisheries resources of Bangladesh was initiated, which hand over the control of the fisheries resources to local communities (Pemsl, D.E. and Seidel-Lass, L., 2010). Several research projects on CBFM in Bangladesh have been coordinated and carried out (Table 6). The goal of these projects was to improve inland fisheries management by fishers playing an active role with the coordination and support from Government of Bangladesh and NGOs and result in a more sustainable, equitable and participatory management of resources.

Table 6. Major Community-Based Fisheries Management Projects in Bangladesh.

Project name (Duration)	Donor (Funds)	Project partners	Water bodies	Summary of major research/activities
Experiments in New Approaches to Management of Fisheries (ENIMPOF) (1987-1990)	Ford Foundation (US$150,000)	World Fish Center, DoF, BCAS	9	Tested government-led licensing strategy to improve inland fisheries management in different types of water bodies; Implementation of different conservation measures.

Improved Management of Fisheries(IMOF) (1991-1994)	Ford Foundation (US$150,000)	World Fish Center, DoF, BRAC, Caritas, Proshika	19	Tested the government and NGO partnership model; Research on awareness and skills training materials for farmers ; Alternative income-generating schemes with financial support; studies to assess improvement of fish production in different water body types.
Community-Based Fisheries Management (CBFM-1) (1995-1999)	Ford Foundation (US$1,800,000)	World Fish Center, DoF, Banchte Shekha, BRAC, Cartitas, CRED, Proshika	19	Tested range of fisheries management models and diverse institutional approaches to developing prototype approach for CBFM and institutional arrangements.
Management of Aquatic Ecosystems through Community Husbandry-Phase 1 (MACH-1) (1998-2001)	USAID (US$6,500,000)	Winrock International, Caritas.	3	Demonstrated that sustainable management of wetlands resources is possible with the participation of stakeholders and users of those resources. It advocated for a multi-disciplinary, multi-sector and participatory process of planning, implementation, and monitoring. Recognizing that the reduction of fishing pressure is a critical part of reviving the wetland fisheries.

Community-Based Fisheries Management (CBFM-2) (2001-2007)	DFID (US$8,376,868)	World Fish Center, DoF, Banchte Shekha, BELA, BRAC, Caritas, CNRS, CRED, FemCom, Gharani, Proshika, SDC, Shisuk	116	Tested developed management systems; Tested mechanism for linking community institutions to better manage larger fisheries systems; Informing and influencing fisheries policy stakeholders.

First two projects were led by World Fish Center in collaboration with the DoF under the government's New Fisheries Management Plan (NFMP), which aimed at replacing the auctioned lease system with an individual licensing scheme to protect the fishing access of genuine fishers from the influential elites (Ahmed, M., Delgado, C. and Sverdrup-Jensen, S., 1997). However, the NFMP was rooted in problem and contradiction in the screening of genuine fishers which was defined as the people whose primary income was fishery related. The inclusion of investors and the screening process was partially implemented by wealthy influential elites defeat the purpose of NFMP (Ali, M.Y., 1997; Huda, A.T.M.S., 2003). Thus, the NFMP was officially ended in 1995 due to its inability to securing fishing access to the poor fishers (Islam, G.N., Yew, T.S. and Viswanathan, K.K., 2014; Sultana, P. and Thompson, P.M., 2007). From the early 1990s, several projects introduced aspects of community-based management to fisheries.

Based on lessons learned from these experimental projects, two successive phases of CBFM projects (CBFM) were officially implemented. The first phase (CBFM-1, 1995-1999) was carried out at 19 sites in 12 districts, and focused on the development of prototype CBFM approaches and institutional arrangements that could be replicated in a broader scope (Pemsl, D.E. and Seidel-Lass, L., 2010; Thompson, P.M., Sultana, P. and Islam, N., 2003). The second phase (CBFM-2, 2001-2007) extended the coverage and included 116 sites in 22 districts. One hundred and thirty Community-Based Organizations (CBOs) which are mostly composed by poor fishers, were constructed to manage water bodies in their proximity. Assistances from partner NGOs included offering training courses in literacy and management, promoting social awareness, and extending credit to finance fisheries and fisheries related activities, with the aim to enhance capacity building for the CBFM organized fishers. Department of Fisheries has provided administrative support to the fishers and enforce the decision that CBOs made.

The CBFM brings together the willingness of all parties (fisher, DoF, and NGO). For the fishers, they seek direct economic benefits associated with better management of a stocked fishery, secure access rights, and attraction to greater participation and equity in management. For the government and NGOs, the motivation lay in their common concern for environmental sustainability, service delivery and desire to bring about sustainable inland fisheries as well as an improvement in the socioeconomic and political conditions of resource users.

Due to the most land area in Bangladesh is covered by Ganges-Brahmaputra delta, there are various type of inland waterbodies (Table 7), including open and closed inland waterbodies and marine water. A *beel* is a lake-like wetland with static water as opposed to flowing water in rivers. Typically, *beels* are formed by the inundation of low-lying lands during flooding, where some water gets trapped even after flood recede from the flood plains. Closed *beels* are smaller and well-defined waterbodies. Open *beels* are larger waterbodies with outlets. *Beels* are extensively used as capture fisheries for subsistence fishing by a wide arrange of stakeholders in Bangladesh. Access rights to *beels* (open and closed *beels*) are established by paying the lease fee to the government revenue department annually. Fishing access in sections of the river was also charged until 1995. The Ministry of Land abolished the lease system for open water bodies (rivers, canals) to “protect the interests of the poor fishermen and make the earning of their livelihood easier” in Bangladesh (Muri, 2003). So, fishing in rivers is a year-long operation with open-access after that. During the rainy season, around 63,000 km^2 of agricultural land (43% of national area) is regularly inundated for about 4 to 5 months. These seasonal appeared depressions are floodplain *beels*, which primarily operated for subsistence needs of the surrounding fishing communities with free entry.

Table 7. The Extent and Distribution of Waterbodies in Bangladesh.

Water resources		Area (km^2)	% of inland waters
Open waterbodies	Floodplains	28,327	93.27%
	Rivers	10,115	
	Beels	1,821	
Closed waterbodies	Ponds	1,468	6.73%
	Oxbow lakes	54	
	Shrimp farms	1,400	

4.3 Data and Methodology

4.3.1 Data

Data was obtained from two sources, (1) the complete household survey data from four sites and (2) site studies for another six sites which reported the central tendency and dispersion of the household survey data. All household surveys used in this study carried out in two successive phases of CBFM project (135 sites in total) in Bangladesh. Nine sites were chosen due to the availability and completeness of the data and site study, and two types of waterbodies were selected for this study: *beel* (annual lease fee is required for access), and river (open access) for impacts comparison of CBFM (Table 8). Respondents had individually interviewed, for both members (treatment group) and non-members (control group) of CBFM, about perceptions of management, fishers' empowerment, fisheries resource and household's livelihood before and after the CBFM. Random samples of 30 households were chosen in both control and treatment group for each site, which added up to a total of 540 households for this study. Household heads were interviewed at both before and after the implementation of either phase one or phase two of CBFM project. Thirteen common indicators (Table 9) were extracted from the household interviews. A quasi-experimental with difference in difference (DID) method (Abadie, A., 2005; Lechner, M., 2010) was applied for the management evaluation to counteract factors that might have impacts upon certain indicators even there had been no intervention at all. The difference between the difference in treatment group (before and after mean score from members) and in control group (before and after mean score from non-members) were further modified as the effect sizes (Unbiased Standardized Mean Difference or Hedge's *g*) in the meta-analyses (Borenstein, M., Hedges, L.V., Higgins, J.P.T. and Rothstein, H., 2009; Hedges, Larry V., Gurevitch, Jessica and Curtis, Peter S., 1999). For perception indicators, the survey employed the existing framework (Likert Scale evaluation) described by Pomeroy and others (1996), which was also employed by many researchers in studies of the Philippines (Baticados, D.B. and Agbayani, R.F., 2000; Katon, B. and Pomeroy, R. S., 1999; Maliao, R.J., 2002; Webb, E.L., Maliao, R.J. and Siar, S.V., 2004)

Table 8. The Sites Selected from Two Phases of CBFM Projects in Bangladesh.

Site	Waterbody	Access	Sample Size
Hamil	*Beel*	Annual Lease	60
Dum Nadi	*Beel*	Annual Lease	60
Dikshi	*Beel*	Annual Lease	60
Goakhola	*Beel*	Annual Lease	60
Chapandaha	*Beel*	Annual Lease	60
Jamalgonj	River (Section)	Open access	60
Arial Kha	River (Section)	Open access	60
Boyral	River (Section)	Open access	60
Magura-Narial	River (Section)	Open access	30

Table 9. The Common Indicators Used to Analyze the Impacts of CBFM in Bangladesh.

Indicators (mean)	**Definition**
Participation	The level of involvement in fisheries management.
Influence	The level of bargaining power over decisions made related to fisheries management.
Compliance	The level of conformity of behaviors with prescribed operational rules and regulations.
Conflict	The incidence of conflict and disputes related to fisheries resource use.
Leadership	The satisfaction of leadership in the fishing community.
Knowledge	The level of knowledge on fisheries management.
Information	The access to the information.
Credit	The amount of credit and interest-free loan received from related institutions.
No. of Sanitary	The number of sanitary latrine in the community.
Employment	The days of employment for a fishing household in a year.
Fishing Income	Total revenues earned from fishing activities for a household in one year.
Non-fishing Income	Total revenues earned from non-fishing activities for a household in one year.
Fish Catch	The amount of fish caught for each household in a year.

4.3.2 Meta-Analysis

It worth mentioning that the meta-analyses (Hedges, L.V., and Olkin, I., 1985) used in this study were primarily the meta-analyses of effect sizes and the ultimate goals are to discover the directions and magnitudes of the summary effect sizes, analyze the dispersion in these effects as well as their magnitudes and causes by categorical analysis (subgroup meta-analyses) (Borenstein, M., Hedges, L.V., Higgins, J.P.T. and Rothstein, H., 2009).

The effect sizes were employed in this study was Hedge's g (g) (Glass, G.V., McGaw, B. and Smith, M.L., 1981; Hedges, L.V., 1981), which is constructed base on the Standardized Mean Difference (SMD) or Cohen's d (d) and fixed the upward bias that inherent in the estimator SMD or d . It is used to quantify the magnitude of the difference between the means of two groups (treatment and control) as a function of the groups' standard deviation and their sample sizes (Borenstein, M., Hedges, L.V., Higgins, J.P.T., and Rothstein, H., 2009). The g can be considered as being comparable across sites based on the argument that it is a measure of overlap between distributions (Hedges, L.V., and Olkin, I., 1985). From this perspective, the g reflects the difference between the distributions in the two groups or how each represents a distinct cluster of scores even if they do not measure the same outcome (Cohen, L.E., and Land, K.C., 1987; Grissom, R.J. and Kim, J.J., 2005). The effect size (g) that used in this study was calculated as shown,

$$Hedges'g\left(g_{ij}\right) = J_j * d_{ij} \tag{4.1}$$

$$J_j = 1 - \frac{3}{4(n_{tj} + n_{cj}) - 9} \tag{4.2}$$

$$d_{ij} = \frac{\left(\overline{x^a_{t\,ij}} - \overline{x^b_{t\,ij}}\right) - (\overline{x^a_{c\,ij}} - \overline{x^b_{c\,ij}})}{s_{pool_{ij}}} \tag{4.3}$$

$$s_{pool_{ij}} = \sqrt{\frac{(n_{tj}-1)\left({S_t^a}^2{}_{ij} - {S_t^b}^2{}_{ij}\right) + (n_{cj}-1)\left({S_t^a}^2{}_{ij} - {S_c^b}^2{}_{ij}\right)}{n_{tj}+n_{cj}-2}} \quad (4.4)$$

where $\bar{x}$ is the sample mean (either of Likert scale perception or value score) of each indicator, n_t and n_t are the sample size in different group (treatment and control), a and b indicate different time point (after and before the intervention), i indicates the specific effect size that constructed by indicator, S^2 is the sample variance, s_{pool} is the pooled sample standard deviation, J_j is the small sample bias correction factor.

The reason that we pool the two sample estimates of the standard deviation is that even if we assume that the underlying population standard deviations are the same, it is unlikely that the sample estimates s_t and s_c will be identical. By pooling the two estimates of the standard deviation, we obtain a more accurate estimate of their common value.

For the sample variance of *d*, Hedges and Olkin (1986) proposed a good estimate and was calculated as,

$$v_{ij} = \frac{n_{tj}+n_{cj}}{n_{tj}n_{cj}} + \frac{{d_{ij}}^2}{2(n_{tj}+n_{cj})} \quad (4.5)$$

In this estimate, the first term on the right of the equation reflects uncertainty in the estimate of the mean difference, and the second reflects uncertainty in the estimate of s_{pool} (Borenstein, M., Hedges, L.V., Higgins, J.P.T. and Rothstein, H., 2009). For obtaining the most precise estimate of the summary effect size for each indicator across all site studies (minimal variance), and comply with large sample theory which states that studies with large samples have more precision, each effect size (*g*) was weighted by the inverse of the its sampling variance as shown,

$$w_{ij} = \frac{1}{v_{ij}} \tag{4.6}$$

It is expected that the true effect sizes differed across all sites of projects, and these differences were not solely due to the sampling error. Logic also dictates that the magnitude of the impact might very depend on the sites of the project, quality of survey design and implementations of intervention, cognitive level of respondents, the attitude of respondents towards the project and program, and so on. Thus, the interventions in these independent sites would have differed in ways that would have impacted on the results. Therefore, the assumption of a common (or fixed) effect size (Hedges, L.V. and Olkin, I., 1985) would no longer be appropriate for this meta-analysis. Thus, the random-effects model, which includes an additional between-studies variance in addition to the original within-study variance, fits this study more precisely (Borenstein, M., Hedges, L.V., Higgins, J.P.T. and Rothstein, H., 2009; Card, N.A., 2012). Therefore, two components of variance were considered in this study, which is the within-study variance (v_{ij}) caused by sampling error and the between-studies variance (${\tau_i}^2$) which reflected true differences among effect sizes of same indicator underlying different site studies. Therefore, the total variance in each site study is the summation of the within-study variance (v_{ij}) and the between-studies variance ${\tau_i}^2$ as shown,

$$V_{ij} = v_{ij} + \tau_i^2 \tag{4.7}$$

For the between-studies variance, DerSimonian and Laird (1986) proposed a method of moment approach, and it was calculated as shown,

$$\tau_i^2 = \frac{Q_i - df}{\sum_{j=1}^{k} w_{ij} - \frac{\sum_{j=1}^{k} {w_{ij}}^2}{\sum_{j=1}^{k} w_{ij}}} \tag{4.8}$$

Q is frequently used for evaluating the heterogeneity (vs. homogeneity) of effect sizes. Q-test involves computing a value (Q) that describes the summation of observed weighted square of the deviation of each effect size from the mean using the following equation (Cochran, W.G., 1954; Hedges, L.V., and Olkin, I., 1985; Lipsey, M.W. and Wilson, D.B., 2001).

$$Q_i = \sum_{j=1}^{k} w_{ij} {g_{ij}}^2 - \frac{\left(\sum_{j=1}^{k} w_{ij}\, g_{ij}\right)^2}{\sum_{j=1}^{k} w_{ij}} \tag{4.9}$$

$$df = k - 1 \tag{4.10}$$

where k is the total number of sites.

This Q test (at a significance level of 0.05) provided us information about the likelihood of results being homogeneous versus heterogeneous but did not reveal the magnitude of heterogeneity if it exists (DerSimonian, R. and Laird, N., 1986). One useful index of heterogeneity in meta-analysis is the I^2 (Higgins, J.P.T. and Thompson, S.G., 2002; Huedo-Medina, T.B., Sánchez-Meca, J., Marín-Martínez, F. and Botella, J., 2006), which is interpreted as the percentage of variability among effect sizes that exists between studies relative to the total variability (within and between studies). But as the nature of meta-analysis across studies, the within-study variance varies from study to study (v_{ij} has two subscripts), so there is no single variance (V_{within}) for all within-study variances. Thus, I^2 index was estimated according to its conceptual definition (Higgins, J.P.T., Thompson, S.G., Deeks, J.J. and Altman, D.G., 2003) as,

$$I_i^2 = \frac{\tau_i^2}{\tau_i^2 + V_{within}} \approx \begin{cases} \frac{Q_i - (k-1)}{Q_i} * 100\% & when\ Q > k-1 \\ 0 & when\ Q \leq k-1 \end{cases} \quad (4.11)$$

I^2 is therefore a readily interpretable index of the magnitude of heterogeneity among studies in meta-analysis, and it is also useful in comparing heterogeneity across different meta-analyses.

Then, the weight assigned to each site under random-effect model was re-calculated as W_i in (4.12) using variance incorporating both components in (4.7). For now, having the effect size of each indicator in every site study and their weights, we were able to calculate the summary mean effect size (weighted mean effect size) for each indicator across all site studies and their variance as shown below.

$$W_{ij} = \frac{1}{V_{ij}} \quad (4.12)$$

$$\bar{\bar{g_i}} = \frac{\sum_{j=1}^{k} W_{ij} g_{ij}}{\sum_{j=1}^{k} W_{ij}} \quad (4.13)$$

$$V_{\bar{\bar{g_i}}} = \frac{1}{\sum_{j=1}^{k} W_{ij}} \quad (4.14)$$

The standard error and its confidence interval (at significance level of 0.05) were calculated afterward as,

$$SE_{\bar{\bar{g_i}}} = \sqrt{V_{\bar{\bar{g_i}}}} \quad (4.15)$$

$$LB_{\bar{\bar{g_i}}} = \bar{\bar{g_i}} - 1.96 * SE_{\bar{\bar{g_i}}} \quad (4.16)$$

$$UB_{\bar{\bar{g_i}}} = \bar{\bar{g_i}} + 1.96 * SE_{\bar{\bar{g_i}}} \quad (4.17)$$

Further, all site studies were categorized by the type of waterbodies (*beels* and rivers) for seeking how the summary effect size of each indicator varied under the influence of implementation location by applying categorical analyses using the Q_{btw} statistic as shown in (4.18). Q_{btw} is structured similarly as Q in (4.9), which just treats the weighted effect size of each indicator in each group as an effect size of a single study. Then Q_{btw} test is used to test the heterogeneity of effect size of single 'studies' similarly to the Q test using the equation (4.9). The significance of both Q and Q_{btw} were tested against the chi-square distribution with $k-1$, $g-1$ degrees of freedom (g is the number of group), respectively. the All meta-analyses were conducted using random-effects model in Comprehensive Meta-Analysis (CMA) version V3.3 (Borenstein, M., Hedges, L.V., Higgins, J.P.T. and Rothstein, H., 2009).

$$Q_{btw} = \sum_{r=1}^{c}\sum_{p=1}^{n_r} w_{pr}\left[g_{pr}\right]^2 - \frac{\left[\sum_{p=1}^{n_r} w_{pr}\, g_{pr})\right]^2}{\sum_{p=1}^{r} w_{pr}} \tag{4.18}$$

where r is the number of groups, n_r is the number of site study in the group r, g_{pr} stands for the effect size of pth site study in the group r, w_{pr} stands for the weight of the effect size of pth site study in the group r.

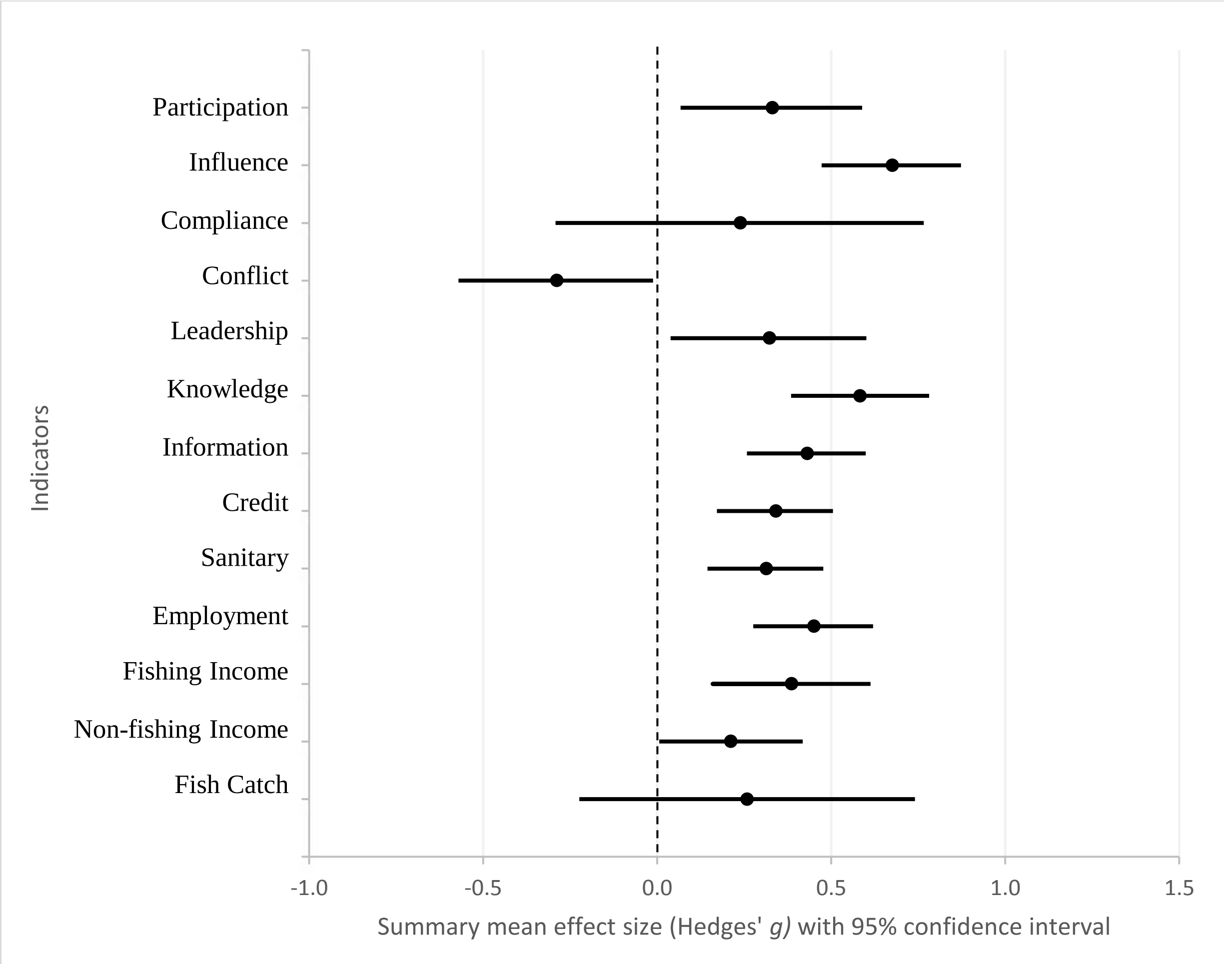
The significance of both Q_i and Q_{btw} were tested against the χ^2 distribution with $k-1$ degrees of freedom. All meta-analyses were conducted using random-effects model in Comprehensive Meta-Analysis (CMA) version V3.3 (Borenstein, M., Hedges, L.V., Higgins, J.P.T. and Rothstein, H., 2009).

4.4 Results

4.4.1 Effect sizes

The effect sizes of CBFM indicated a positive change in all chosen indicators for included sites in Bangladesh (Figure 4). For the summary effect sizes of management related indicators, *Participation* ($\bar{\bar{g}} = 0.331, CI = 0.073, 0.589$), *Influence* ($\bar{\bar{g}} = 0.676, CI = 0.478, 0.873$), *Compliance* ($\bar{\bar{g}} = 0.240, CI = -0.286, 0.766$), and *Leadership* ($\bar{\bar{g}} = 0.323, CI = 0.044, 0.601$) were perceived to increase, while *Conflict* ($\bar{\bar{g}} = -0.289, CI = -0.565, -0.0121$) was perceived to decrease after the implementation of CBFM. For the summary effect sizes of empowerment, *Knowledge* ($\bar{\bar{g}} = 0.583, CI = 0.385, 0.781$), *Information* ($\bar{\bar{g}} = 0.431, CI = 0.264, 0.599$), and *Credit* ($\bar{\bar{g}} = 0.431, CI = 0.177, 0.505$) were perceived to increase after the implementation of CBFM. For the summary effect sizes of livelihood, *No. of Sanitary* ($\bar{\bar{g}} = 0.314, CI = 0.150, 0.477$), *Employment* ($\bar{\bar{g}} = 0.451, CI = 0.282, 0.620$), *Fishing Income* ($\bar{\bar{g}} = 0.386, CI = 0.160, 0.613$), *Non-fishing Income* ($\bar{\bar{g}} = 0.212, CI = 0.006, 0.418$), and *Fish Catch* ($\bar{\bar{g}} = 0.258, CI = -0.224, 0.741$) were all perceived to increase as well. It is easily noted from the figure below that all effect sizes were statistically significant except for *Compliance* and *Fish Catch*.

Figure 4. Summary effect sizes of community-based fisheries management projects in Bangladesh based on thirteen common indicators.



4.4.2 Heterogeneity Analysis and Categorical Meta-Analyses

However, nearly half of all indicators were discovered to show heterogeneity in their effect sizes across sites after applying the homogeneity test ($\mathrm{Q-test}$ in Table 10), which indicated that there were some true differences in effect size across sites and those variations were not fading out if sample size has dramatically increased. The magnitude of heterogeneity in effect sizes across sites was quantitatively measured by the percentage of I^2, which represents the extent of overlap of confidence intervals and serves as a measure of inconsistency across the findings of the studies (Borenstein, M., Hedges, L.V., Higgins, J.P.T. and Rothstein, H., 2009; Card, N.A., 2012).

The sites were then categorized into two groups by the type of waterbodies (*beel* and river) and conducted separate meta-analyses (Figure 5 and 6) and categorical analysis (Table 10) between the groups to further explain the reason for that heterogeneities. The effect sizes of CBFM were perceived quite differently in the two groups that categorized by the type of waterbodies. For the sites fishing on *beels*, all indicators showed positive mean score in summary effect sizes except for the *Conflict*. For the other group with sites fishing on rivers, the indicators of *Participation*, *Compliance*, and *Fish Catch* showed negative mean score in their summary effect size, while all other indicators were positively perceived in their mean score of summary effect sizes.

Moreover, the difference in weighted effect size (subgroup summary effect size) of each indicator between two groups was further tested, and the results revealed the between-group difference in effect sizes of *Participation* ($Q_{btw} = 12.94, SD = 0.169$), *Influence* ($Q_{btw} = 5.08, SD = 0.172$), *Compliance* ($Q_{btw} = 3.87, SD = 0.481$), *Conflict* ($Q_{btw} = 6.07, SD = 0.223$), *Fishing Income* ($Q_{btw} = 5.98, SD = 0.183$), and *Fish Catch* ($Q_{btw} = 3.80, SD = 0.425$) with statistically significant. As for other effect sizes, although they were not showing statistical significant changes (Table 10), the difference between two groups of their true effect can also be calculated, which fall in the range of -0.11 to 0.94 (*Leadership*), -0.48 to 0.29 (*knowledge*), -0.12 to 0.54 (*Information*), -0.26 to 0.40 (*Credit*), -0.35 to 0.31 (No. of *Sanitary*), -1.06 to -0.38 (Employment), and -0.21 to 0.62 (Non-fishing Income) as showing below.

Table 10. Heterogeneity Test of Effect Sizes and Categorical Analysis in Bangladesh.

	Heterogeneity test of effect sizes			Categorical meta-analysis between two waterbodies			
Indicators	$Q - \text{stat.}$	P-value	I^2 −stat	$Q_{btw.} - \text{stat.}$	P-value	Std. Error	Confidence Interval
Participation	19.62	0.012	59.23	12.94	0.000	0.169	(0.27, 0.94)
Influence	11.08	0.197	27.80	5.08	0.024	0.172	(0.05, 0.72)
Compliance	77.41	0.000	89.66	3.87	0.049	0.481	(0.00, 1.89)
Conflict	21.42	0.006	62.66	6.07	0.014	0.223	(-0.99, -0.11)
Leadership	22.79	0.004	64.89	2.44	0.118	0.266	(-0.11, 0.94)
Knowledge	11.34	0.183	29.50	0.21	0.650	0.195	(-0.48, 0.29)
Information	8.30	0.404	3.70	1.53	0.216	0.169	(-0.12, 0.54)
Credit	6.21	0.623	0.00	0.06	0.815	0.168	(-0.26, 0.40)
No. of Sanitary	4.90	0.768	0.00	0.70	0.403	0.168	(-0.35, 0.31)
Employment	7.90	0.443	0.00	3.47	0.062	0.174	(-1.06, -0.38)
Fishing Income	15.13	0.057	47.14	5.98	0.015	0.183	(-0.80, -0.09)
Non-fishing Income	12.70	0.122	37.03	0.91	0.340	0.212	(-0.21, 0.62)
Fish Catch	66.08	0.000	87.89	3.80	0.051	0.425	(0.00, 1.66)

Figure 5. Summary Effect Sizes of CBFM for Fisheries in Beels in Bangladesh.

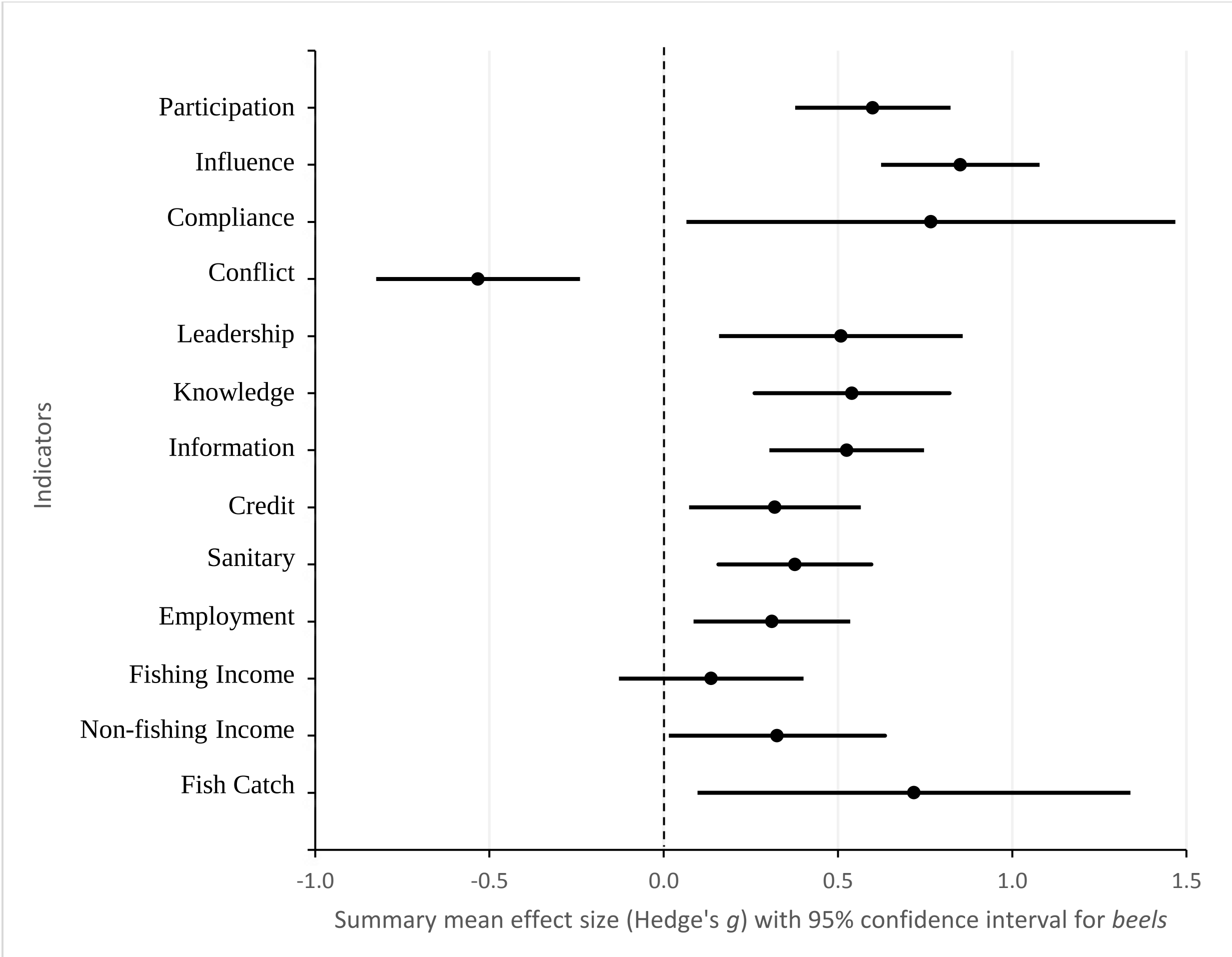
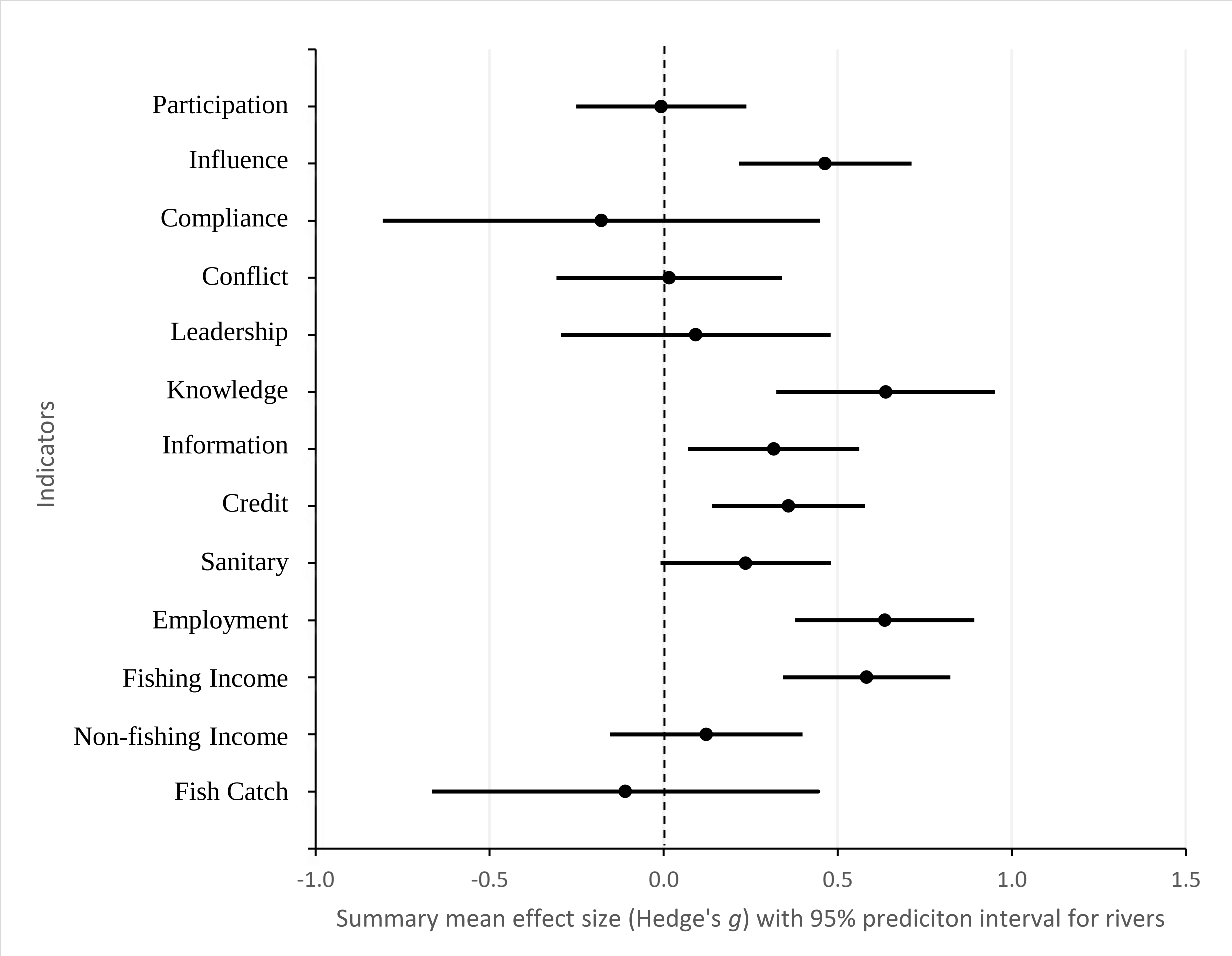


Figure 6. Summary Effect Sizes of CBFM for Fisheries in Rivers in Bangladesh.



4.5 Discussion

For all 13 indicators, summary effect sizes in the aspect of management, empowerment, and livelihood were perceived to be fairly positive for the implementation of CBFM overall. However, the magnitude of effect sizes in each aspect was revealed quite differently, and even the effect size for the same indicator was also varied when it was sub-grouped by the type of waterbodies. More details were discussed below in four dimensions: management, empowerment, livelihood, and fisheries resource.

According to the Cohen (1988) with small sample bias correction (Table 11), the CBFM intervention had "large effect" on *Influence* and *Knowledge*, "medium effect" on

Participation, *Compliance*, *Conflict*, *Leadership*, *Information*, *Credit*, *No. Sanitary*, *Employment*, and *Fish Catch*, "small effect" on *Fishing income*. For more concrete understanding of effect size (g) for all effect sizes, Cohen's U_3 and Probability of Superiority were showed in Table 11 for reference. Take the effect size of Participation for example, Cohen's U_3 informed us that 63% of the treatment group will be above the mean of the control group, and, by Probability of Superiority, there is a 59% chance that a person *pi*cked at random from the treatment group will have a higher score than a person picked at random from the control group (probability of superiority).

Table 11. Indications of Effect Sizes in CBFM In Bangladesh.

Effect size (g)	Cohen's U_3 (%)	Probability of Superiority (%)
Participation	62.93	59.23
Influence	74.86	68.22
Compliance	59.48	56.74
Conflict	61.03	57.85
Leadership	62.55	58.95
Knowledge	71.90	65.91
Information	66.64	61.95
Credit	63.31	59.50
No. of Sanitary	62.17	58.68
Employment	67.36	62.48
Fishing Income	56.36	54.50
Fish Catch	59.87	57.02

Cohen's U_3 indicates the percentage of treatment group is above the mean of the control group.
The probability of Superiority indicates the likelihood that a person picked from the treatment group randomly have a higher score than a person picked from the control group randomly.

4.5.1 Management

The summary effect sizes of management related indicators include *Participation* ($\bar{\bar{g}} = 0.331, CI = 0.073,0.589$), *Influence* ($\bar{\bar{g}} = 0.676, CI = 0.478,0.873$), *Compliance* ($\bar{\bar{g}} = 0.240, CI = -0.286,0.766$), *Conflict* ($\bar{\bar{g}} = -0.289, CI = -0.565, -0.012$), and *Leadership* ($\bar{\bar{g}} = 0.323, CI = 0.044,0.601$). other than the effect size of *Compliance*, all other ones in the summary effect size of management are statistically significant.

One of the rationales for the CBFM was that fishers in Bangladesh are poor regarding their incomes and livelihood assets, and lack a role in decisions about the future of the resources that they and their families depend on deeply (Thompson, P.M., Sultana, P. and Islam, N., 2003). The performance gained in the indicator of Participation, Influence and Leadership justified the positive impacts of CBFM on the capability of organizing fishing communities and involving fishers in making decision on the resource exploitation. Thompson and others (2003) found out that the CBFM did increase participation in decision-making, and boost great cooperation among fishing households and even fishing communities in some cases. In another study, Kabir and others (2011) indicated that the respondents are now more organized in terms of their willingness to attend the meetings regarding fisheries management as well as other community affairs and much-improved influence on these issues. With studies employing Principal Component Analysis (PCA) in CBFM, *Participation*, *Influence* and *Leadership* were also revealed as higher factor loadings (Islam, G.M.N. and Yew, T.S., 2013; Kabir, G.M., Yew, T.S., Noh, K.M. and Hook, L.S., 2011; Lise, W., 2000; Pomeroy, R.S., Katon, B.M. and Harkes, I., 2001).

The negative effect size of *Conflict* with statistical significance indicated that the violence happened during fishing practices and community affairs were decreased dramatically. Combining with the improved performance on *Compliance*, CBFM portrayed a less colliding, more harmonious manner of fishing activities and community atmosphere. Pomeroy and others (2007) indicated that declining fish stock leads to high levels of conflict among different users over the remaining stocks, which in turn driving fishers to employ more destructive and over-efficient fishing technologies. Thus, the appropriate incentives for sustainable exploitation of fisheries resource must be instituted and complied with by its users, fishers (Pomeroy, R.S. and Viswanathan, K.K., 2003; Tawake, A., Parks, J., Radikedike, P., Aalbersberg, W., Vuki, V. and Salafsky, N., 2001). A study in livelihood improvement for fishers in Senegal (Lenselink, N.M., 2002) indicated that a long-standing conflict between local fishers and outsiders was successfully resolved by a local fishing committee that was never established before.

While the indicators of management related were shown to be greatly improved by implementation of CBFM, the heterogeneity of effect size was detected in *Participation* ($Q = 19.62, I^2 = 59.23$), *Compliance* ($Q = 77.41, I^2 = 89.66$), *Conflict* ($Q = 21.42, I^2 = 62.66$), and *Leadership* ($Q = 22.79, I^2 = 64.89$). Higher percentage of I^2implied the relative large differences in effect size across sites for these indicators. By conducting categorical analyses in different type of waterbodies, the results revealed the close relationship between types of waterbody and the most effect sizes (*Participation*, *Compliance* and *Conflict*) with heterogeneity in management. The sites around *beels* have much better performance in these three indicators, not only by their large effect sizes, but also the statistically significant difference compared to the sites around rivers. With its relative easy defined boundary and exclusive access, fishers who paid the lease have stronger incentives and willingness to participate in the fisheries management, to make their voice heard and mattered, to follow the rules and regulations and take the responsibility of monitoring. Comparing to the sites around rivers also in CBFM, competition from outsiders are the major factor that weaken the management of community-based fisheries (Islam, G.M.N. and Yew, T.S., 2013). Smaller effect sizes of Participation indicated that fishers were less willing to involve in fisheries management and their insufficient confidence in CBFM. The lower effect size of *Leadership* also revealed the less satisfactory that fishers perceived in the CBFM. In addition, the effect size of *Compliance* with a wide prediction interval across the zero indicated that there was a quite mixed performance in compliance of rules and regulations that made by fisheries communities and Department of Fisheries. Some studies suggested that compliance was close related to the scale of target, which indicate a high level of compliance likely to be presented in larger groups where there is peer pressure and altruistic punishment (Fehr, E. and Fishbacher, U. , 2003; Jentoft, S. and McCay, B.J., 2003). However, in another study on three *beels* indicated that compliance was revealed in smaller and more homogeneous communities (Sultana, P. and Thompson, P.M., 2007). Overall, the nature of open access in rivers could contribute to the poor performance of CBFM in terms of organizing fishers and making them self-initiated for sustainable fishing practices (Pretty, J.N., Guijt, I., Thompson, J. and Scoones, I., 1995; Thompson, P.M., Sultana, P. and Islam, N., 2003) based on the comparison with the better defined access right in *Beels* in this study. Under the CBFM project, rights of resource management were transferred to the local fishing communities, with the administrative support from government and facilitation of NGOs. Increased participation of the organized fishers in decision making has contributed to a better management of the fisheries and therefore improved livelihood. The households under CBFM have increased their participation in not only fishing activities, but also community affairs, which result in a better influence power and greater compliance with local fisheries rules and regulations, and effective conflict resolving mechanism (Islam, M.A., Majlis, A.B.K. and Rashid, M.B., 2011).

4.5.2 Empowerment

The summary effect sizes of empowerment related indicators include *Knowledge* ($\bar{\bar{g}} = 0.331, CI = 0.073{,}0.589$), *Information* ($\bar{\bar{g}} = 0.676, CI = 0.478{,}0.873$), and *Credit* ($\bar{\bar{g}} = 0.240, CI = -0.286{,}0.766$). All three medium effect sizes with statistically significance revealed that the level of fishers' empowerment in inland fishery management in Bangladesh has improved significantly under the CBFM.

Low level of formal education is prevalent in fishing communities of Bangladesh. Through CBFM project, partner NGOs conducted awareness campaigns and training programs on many issues regarding community fisheries, such as, accounting management, fish processing, sustainable harvesting, and alternative income generating activities to improve fishers' level of knowledge. The effect sizes of empowerment indicators were perceived to be consistent across all sits included in this study by showing no statistical significance in the heterogeneity test. The consistency was also caught by the magnitude measure of the heterogeneity (I^2), the largest score of the three, *Knowledge*, showed less than one third of the variation attributing to between-sites variation.

The attainment of knowledge and information exchange among the fishers was crucial in the CBFM (Islam, G.M.N. and Yew, T.S., 2013; Pomeroy, R.S. and Viswanathan, K.K., 2003). Through producing newsletters, audiovisual materials and organizing TV talk shows by partner NGOs in the CBFM sites, fisheries knowledge and information were effectively disseminated and exchanged in all sites (Islam, G., Yew, T.S., Abdullah, N.M.R. and Viswanathan, K.K., 2011). The unhindered knowledge attainment and information exchange also contribute to the credit distribution. Studies reported that community organized fishers received larger amount of credits from not only the partner NGOs, but also other interest free loan from other institutions comparing to the non-CBFM fishers (Islam, G., Yew, T.S., Abdullah, N.M.R. and Viswanathan, K.K., 2011; Islam, G.M.N. and Yew, T.S., 2013). The credit received from NGOs was utilized for various productive purposes, which included paying lease fees and investment in alternative income generating activities. Sultana and Thompson (2007) also found that more than half of these funds were used for non-fishery related income-generating activities. With more understanding of vulnerability that caused by deep dependency on fisheries, fishers were more aware of the importance of livelihood diversification.

4.5.3 Livelihood

The summary effect sizes of livelihood related indicators include *No. of Sanitary* ($\bar{\bar{g}} = 0.314, CI = 0.150, 0.477$), *Employment* ($\bar{\bar{g}} = 0.451, CI = 0.282, 0.620$, *Fishing Income* ($\bar{\bar{g}} = 0.386, CI = 0.160, 0.613$), and *Non-Fishing Income* ($\bar{\bar{g}} = 0.212, CI =$

$0.006, 0.418$), and *Fish Catch* ($\bar{\bar{g}} = 0.258, CI = -0.224, 0.741$). other than the effect size of *Fish Catch*, all other ones in the effect size of livelihood related indicators were statistically significant.

As the most important indicators of livelihood, *Employment* and *Income* were perceived to improve under the CBFM for all selected sites in this study. More days of employment was perceived to be a common change (medium effect size) across all sites, because it was not detected by the heterogeneity test and reflected by a very low I^2, which indicated there was no evident true difference between sites. As mentioned previously in management and empowerment related indicators, more interactions were established between fishers and other stakeholders by attending community meeting and public gatherings. Thus, fishers were more empowered by various information attainment. One of the most important information was the credit support and income generating potentials, which could have directly impact on the livelihood of fishing households. Giving the already overcapacity of fishing activities before the CBFM (Hanna, S., 1995; McCay, B.J., 1996; Muir, J.F., 2003; Pomeroy, R.S., 1995), the increased day of employment was mainly from the involvement of activities from other sectors (Kabir, G.M., Yew, T.S., Noh, K.M. and Hook, L.S., 2011). Agriculture and small businesses were the most chosen alternatives, which was mainly attributed to the supports from NGOs (Craig, J.F. , Halls, A.S., Barr, J.J. and Bean, C.W., 2004; Thompson, P.M., Sultana, P. and Islam, N., 2003). It has been reported by several authors that through the community-based approach, fishers have managed to be employed and more income generated (Hossain, M., Islam, K. and Andrew, J., 2006; Sarker, A.C., Sultana, P. and Thompson, P. , 1999; Thompson, P.M. and Hossain, M.M., 1998). In addition, Thompson and others (2003) found that fishers working in rivers tended to utilize the credit for investing in the equipment of fish processing other than in the equipment of harvesting.

The effect sizes of income were perceived positive with statistically significant for both from fishing activities ($\bar{\bar{g}} = 0.212, CI = 0.006, 0.418$) and non-fishing activities ($\bar{\bar{g}} = 0.386, CI = 0.160, 0.613$). For the *Fishing Income*, although the heterogeneity test did not pick up any significant variations across the sites, the somehow tricky P-value (0.057) and the underlying difference between waterbodies suggest prudent statement. Magnitude measure of heterogeneity I^2 (47%) further indicated that the heterogeneity was not negligible. The access rights were established differently between *beel* and river in Bangladesh as mentioned before, and the impacts of this difference reflected in the effect size of *Fishing Income*. Indeed, the summary effect size of fishing income was perceived differently with statistically significance between *beels* and rivers through categorical analysis. And the weighted effect size of *Fishing Income* in *beels* was smaller than fishing income in rivers by subgroup meta-analysis.

The summary effect size of *Fishing Income* was perceived as a small positive with statistical significance, which indicated a better utilization of the fisheries resources under CBFM. While the contrast in effect size between waterbodies was mostly due to the higher cooperation cost in *beels* and free access to rivers (Islam, G.N., Yew, T.S. and Viswanathan, K.K., 2014; Khan, F., Mustafa, M.G. and Naser, N.M., 2016). Fishing in *beels* did not only require leasing fees, but also stocking expenses for most of the *beels* due to the specific ecosystem. Unlike the flowing river, most *beels* are static water with no effective replenishment of fish stock. Thus, stocking was required for most fishing communities that are operating in the *beels* (Islam, G.M.N. and Yew, T.S., 2013). However, the summary effect size of *Non-Fishing Income* was telling a different story, with *beels* having a larger effect size than rivers with statistically significance, which indicated that fishers working in *beels* did a better job in income diversification, even they had less revenue from fishing. This interesting result further emphasized the crucial role of Participation in the CBFM. Just as White and Vogt (2000) (White, A.T. and Vogt, H.P., 2000) suggested that good participation has resulted in positive behavioral changes, even lack of tangible benefits at the household level. Roy and others (1999) also explained this behavioral change as the sufficient satisfaction with perceived non-tangible improvements. Similar findings were also indicated by other studies (Juinio-Menez, M.A., Salmo, S., Tamayo, E., Estepa, N., Bangi, H. and Alino, P., 2000). These positive behavioral changes are vital to the sustainability of both CBFM and fisheries resource, which is a promising impetus to reversing the "negative feedback cycle" that Pomeroy and other (2007) described.

Other than *Employment* and *Income*, the summary effect size of *No. of Sanitary* indicated a clearly improvement in livelihood with no heterogeneity detected and consistent across waterbodies under CBFM. As an important indicator for rural livelihood (Pritchard, M., Kenward, S. and Hannan, M., 2015), the increased number did not only imply the improvement in access, but more importantly, the improvement in health awareness in rural villages, which further boost the standard of living in sanitation regard.

The summary effect size of *Fish Catch* was perceived as a small positive effect ($\bar{\bar{g}} = 0.258, CI = -0.224, 0.741$). Although the effect size was not statistically significant, it ranged from a small negative effect to a medium positive effect. Heterogeneity of this effect size was detected with large magnitude ($I^2 = 87.89\%$), which revealed inconsistent effect size across sites. The summary effect size of *Fish Catch* was perceived smaller in the rivers than it was previewed in the *beels* with statistically significance, which was in accord with the inconsistency existed in summary effect size of *Fishing Income* shown above. The larger effect size of *Fishing Income* in river was due to the better utilization of fisheries resource under the CBFM which is the same reason as the positive effect size of *Fishing Income* across all sites. While the lower effect size of *Fish Catch* in river indicated that overfishing was still present due to the limitation of CBFM in the waterbody with free access. Also, due to the extent of annual flood is variable and unpredictable, fisheries in rivers is more vulnerable, therefore more likely to fluctuate comparing to *beels* (Craig, J.F., Halls, A.S., Barr, J.J.F. and, Bean, C. W., 2004). It was worth noting that there was a fairly larger effect size of *Fish Catch* in waterbody of *beels*, which was mostly due to its stocking system and restricted access.

4.6 Conclusion

The overall outcomes of meta-analyses in this study revealed positive impacts of CBFM on the fisher's livelihood, sustainable fisheries management, and fisher empowerment in Bangladesh by investigating the effect sizes of 13 common indicators.

The positive summary effect sizes of *Participation*, *Influence*, *Conflict*, and *Leadership* conjunctly indicated that fishers under CBFM are now more organized in terms of their willingness to attend the meetings regarding fisheries management as well as other community affairs and a less colliding, more harmonious manner of fishing activities and community atmosphere. The positive summary effect sizes of *Knowledge*, *Information*, and *Credit* revealed that the level of fishers' empowerment in inland fishery management in Bangladesh has improved significantly under the CBFM, and this empowerment improvement will be the catalyst for further CBFM or any fisheries management projects. With more understanding of vulnerability that caused by deeply dependency on fisheries, fishers were more aware about the importance of livelihood diversification which revealed by the positive summary effect sizes of both *Incomes*. Therefore, not only the fisher's livelihood becomes more resilient, also the overfishing and overcapacity that are well recognized as the self-enforced issue are expected to alleviate. Although the summary effect size of *Compliance* and *Fish Catch* showed no statistically significant, the effect size of each of them showed statistically significant difference between two types of waterbodies. The *beels* with entray restriction had better performance in most indicators, including *Fish Catch* and *Compliance*, but with a higher operation cost. The rivers had a better performance in *Fishing Income* and *Employment* with its open access, but the lower *non-fishing Income* revealed its deeper dependency on the fisheries resource and less sustainability. Also, the competitiveness from outsiders and higher vulnerability from rainy season also differed the effect sizes of *Participation*, *Influence*, and *Conflict* between household fishing in beels and rivers statistically significant.

Inland fisheries of Bangladesh are complex, dynamic and valuable in the same time. Most of the population exploit the rich and productive fish for food and income generating on a seasonal basis, complementing their agricultural activities and taking advantage of the natural variations in fish catch ability during the flood cycle. With its unique flood pulse, complex institutional arrangement and access rights are the determinant factors in the distribution of benefits among fishers practicing in various water bodies. The Government of Bangladesh is increasingly devolving management responsibility to local communities, encouraging a more adaptive and participatory approach on a local scale. The advantages of CBFM include an enhanced sense of ownership which encourages the fishing activities in a more responsible and less regardless manner, greater sensitivity to local socioeconomic and ecological restraints, improved management through utilization of local knowledge, collective decision-making, increased compliance with regulations through peer pressure, and better monitoring, control and surveillance by fishers in the communities.

In a closed system, such as permanent water bodies, this is much easier to achieve and to spread the benefits to all participants. While the open access policy for most rivers and extensive floodplains, which leads to a severe competition of fisheries resources, reduces the potential effectiveness of CBFM. Thus, access control is needed as a protection of the effectiveness of CBFM. However, the way of establishing access must be considered seriously because the fisheries also play a circuital role as social safety net. Hoggarth and others (1996) suggest that effective management requires a holistic and multi-disciplinary approach that better adaptive management, which is flexible and appropriate to meet the local needs. Therefore, the creation and promotion of alternative livelihood strategies for these groups may be a prerequisite for the sustainable fisheries management. It is important to note that Pomeroy and others (1996) suggest that fisher like their occupation and would not necessarily change to another occupation. Thus, the development of supplemental rather than alternative occupations may be a more realistic goal. Thus, the access control must be implemented along with the alternative or supplemental employment creation. By limiting the fishing effort of fishers who have supplement or alternative employment and turning full-time fisher to part-time fisher with supplement or alternative employment would be a promising approach to introduce access control. In this regard, studies suggest that pen and cage culture are very suitable for the floodplains in Bangladesh, which could be a great supplement of fish production for the country (Gupta, M.V., Sollows, J.D., Mazid, M.A., Rahman, A., Hussain, M.G. and Dey, M.M., 1998; Karim, H., 1988).

The overall management of inland open waters is complex. They are the primary source of food for the common people of Bangladesh. Therefore, even a small increase in growth in this sector is bound to have a major impact. Efforts to protect, rehabilitate and maintain water bodies and thereby conserve aquatic biodiversity have not yet been undertaken seriously in Bangladesh. As there is open access for fishing in open water bodies, increased production from this recourse will massively improve both food consumption and livelihoods, particularly for subsistence fishers and their families. This study was not an exhausted performance evaluation due to the limited projects selection, but it does shed some lights on the impacts of CBFM on and fisheries management, fisher empowerment and fishers' livelihood by two types of water bodies. This study also provided a first attempt to analyze the effect sizes of CBFM in Bangladesh by utilizing random effect model in the meta-analysis, which is capable of not only testing the significance of the effect but more importantly, quantifying the magnitude of the intervention effect. Other than narrative synthesis, which suffers from the subjectivity of drawing a conclusion from various studies, meta-analysis is capable of statistically synthesizing the data to discover the direction and magnitude of the overall effect, in a transparent, objective, and replicable manner through weighting each qualified study (Borenstein, M., Hedges, L.V., Higgins, J.P.T. and Rothstein, H., 2009). Moreover, the results could be used as relevant information for institutions who want to apply community-based fisheries for rural development.

CHAPTER V

THE IMPACT OF COMMUNITY-BASED FISHERIES MANAGEMENT (CBFM) ON EQUITY AND SUSTAINABILITY OF SMALL-SCALE COASTAL FISHERIES IN THE PHILIPPINES

5.1 Introduction

With the total number of 7,101 islands, the 5th longest coastline (36,289 km) in the world, and over 2.2 million km^2 of seas, the Philippines is the world's second largest archipelagic country and is recognized by the major fish producing countries in the world (Green, S., White, A., Flores, J., Careon, M., Sia, A., 2003). Various socio-economic data indicate that the ability of the sea to provide a source of food and income for the Filipino has been severely compromised (FAO, 2014; Kishigami, N., Savelle, J.M., Kokuritsu, M.H., 2004; McClanahan, T.R., Castilla, Z.J.C., Wiley, I., 2007; Pomeroy, R.S., Pollnac, R., Predo, C., Katon, B., 1996). With the combination of significant pouring of foreign investment and the export-orientated fisheries policy of the Philippines' government, virtually all fishing grounds are being overexploited and seriously devastated. Total capture fisheries production has been constant, if not declined, for more than a decade (Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S., Ahmed, M., 2003; Pomeroy, R.S., Parks, J., Mrakovcivh, K.L., LaMonica, C., 2016; Pomeroy, R.S., Viswanathan, K.K., 2003; World Bank, 2013). For coastal residents, the combined effect of overfishing and overcapacity do result in a steady reduction in their standard of living (Béné, C., Neiland, A., Jolley, T., Ladu, B., Ovie, S., Sule, O., Baba, O., Belal, E., Mindjimba, K., Tiotsop, F., Dara, L. Zakara, A., Quensiere, J., 2003). The average annual wage of a crew member was estimated less than a fourth of the poverty line (Chen, S., Ravallion, M., 2001; Barut, N.C., Santos, M.D., Mijares, L.L., Subade, R., Armada, N.B., Garces, L.R., 2003). Studies in the Philippines, Bangladesh, Malawian, and Chad found that fish produced by common-pool resources or aquaculture is sold for cash to exchanging cheaper staple foods, rather than as direct food consumption (Béné, C., Neiland, A., Jolley, T., Ladu, B., Ovie, S., Sule, O., Baba, O., Belal, E., Mindjimba, K., Tiotsop, F., Dara, L. Zakara, A., Quensiere, J., 2003; Islam, F.U., 2007; Karim, M., 2006; Kawarazuka, N., 2010). Comparing with the country-level statistic that more than 40 percent of the protein intake (42.5%) are from fish, this percentage significantly increased to 76 for the low-income household, mostly small-scale fishers (Mohan, D.M., Rab., M.A., Paraguas, F.J., Piumsombun, S., Bhatta, R., Ferdous, A.M., Ahmed, M., 2005), which revealed a deeper dependency on fisheries resource for fishing communities.

The small-scale fishers in the Philippines are marginalized as well regarding its political and economic status in the Philippines. The poverty reduction policies have largely failed to reach small-scale fishers. Low-interest loan. Therefore, the pattern of export-oriented fisheries trade that was forged by foreign investment not only significantly lowered the productivity of small-scale fisheries but also further marginalized, both politically and economically, the small-scale fishers who are deeply dependent on traditional fishing gear and desperately seek to meet local subsistence requirement. With the development of the country, small-scale fishers fall deeper in a situation of a lower standard of living, deeper dependency on the resource, and most importantly, the weaker ability to reverse the two.

Community-based fisheries management (CBFM), as an approach of people-centered, community-orientated and resource-sustaining, are urgently expected to address these issues. Although it is still not fully developed and in small number comparing to the CBFM of forestry and irrigation, the Philippines, comparing with other countries in the world, has the most number of the CBFM projects and programs. Thus, with extensive input of time and money as well as the collective efforts of different communities, organizations, and institutions, experiences and knowledge have derived and accumulated during the implementation of the projects and programs. It would be such a waste if all these experiences were only useful to their implementation. Moreover, they are deserved to be the generator of deeper understanding and valuable knowledge as guidance for future participants and implementers of similar projects and programs. Although there are some fairly comprehensive studies on the CBFM projects and programs in the Philippines, they were separate studies which either focused on one project or program at a time or presented as a descriptive synthesis (Agbayani, R. F., 1995; Amar, E., Cheong, R., Tambasen-Cheong, V., Clarissa, L., Garcia, L., Ma, B., 2009; Katon, B., Pomeroy, R.S., 1999; Pomeroy, R.S., Pollnac, R., Predo, C., Katon, B., 1996). Unfortunately, they did not present general effects sizes and their pattern during the implementation and lack the ability to reveal the true effect differences (population variability) and their magnitude of such projects and programs

This study aims to analyze the impact of CBFM on the equity and sustainability (Hanna, S., 1995) of small-scale fisheries based on 31 sites in 13 projects and programs in the Philippines by using meta-analysis and meta-regression (Smith, M.L., Glass, G.V., 1977). The specific objectives of this study are: (1) describing the characteristics of projects and programs of CBFM in the Philippines; (2) assessing the impacts of CBFM project and programs on sustainability of both fisheries resource and management as well as the equity of both involvement in management and benefit sharing in fishing communities, in both magnitude and heterogeneity dimensions; (3) identifying the most determining factors for the sustainability and equity during the implementation. This study provided a critical assessment of the impacts of completed CBFM projects and programs on sustainability and equity issues to serve as a basis for improving planning and implementation of further projects in the Philippines.

5.2 Community-Based Fisheries Management (CBFM)

With the combined threats and pressures associated with it, fishery in the Philippines is more than an economic surplus generating sector in trade. It is closely bound up with the daily life of each fishing household and any other people whose livelihood are associated with fisheries. Despite a long history of existence, Philippines fisheries have yet to be sustainably managed (Muallil, R.N., Cleland, D., Alino, P.M., 2013; Muallil, R.N., Mamauag, S.S., Cababaro, J.T., Arceo, H.O., Alino, P.M., 2014; Pomeroy, R.S., Andrew, N., 2011; Pomeroy, R.S., Berkes, F., 1997; Pomeroy, R.S., Viswanathan, K.K., 2003).

More experts on fisheries management recognize and suggest that the underlying causes of fisheries resource over-exploitation and coastal environment degradation are often of social, economic, institutional origins (Pomeroy, R.S., 1995). The conventional management has been widely realized part of the problem rather than of the solution of resource overexploitation because it overlooked the critical role that resource users played which did not suit for developing countries with limited financial means and expertise to manage fisheries resources in widely dispersed fishing grounds (Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R.S., 2001). Thus, the focus of fisheries management should shift to the actual resource user, fishers, instead of the resource itself. However, incorporating fishers in the target of fisheries management is only the first step of the solution and is not sufficient by any means. As the resource user, all fishing activities and the way of organizing livelihood are based on their actual needs with the specific condition that varies across villages. Because of the dynamic and complex in the process of resource exploitation and utilization, any static and universal approach will not work in this setting. Thus, incorporating fishers in the process of making management plan of fisheries resources is vital in terms of feasibility and validity.

The transition of fisheries management, from stock and species-based harvest-orientated top-down legal mandates of the 1970s and 1980s to ecosystem and community-based conservation orientated management (Table 12), have been increasingly recognized and widespread (Ferrer, E.M., Cruz, L.P., Domingo, M.A., 1996; Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R.S., 2001).

Table 12. Fisheries Management Transition in The Philippines.

	1950s-1960s	1970s-1980s	1990s-Present	
Demand does not surpass supply	Coastal resource development promoted by national government	Regulation of coastal resources instituted by national government	National legal and policy framework for coastal management established	Coastal management devolved to the local government as a basic service
	Fishers exploit coastal resources with open access	Community-based resource management models developed	Community-based resource management institutionalized	

Harvest-orientated → Conservation-orientated

The new approach highlights the capability of local resource users by participatory planning and implementation as well as decentralization of the management authority and responsibility to the local level (Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R.S., 2001). The increased attention paid to community-based fisheries management has come about through experience of the poor performance of other approaches and through the study of traditional systems of community management of natural resources which have not only survived but also appear to perform better than the alternatives (Thompson, P.M., 1999).

It starts from the basic premise that people have the innate capacity to understand and act on their problems and bases on where the people are, what the people already know, and develops further knowledge and create consciousness (Ferrer, E.M., Nozawa, C.M.C., 1997). With its community-orientated, fisher-centered characteristic, community-based management is capable of developing the management strategy that caters the specific needs based on local conditions. Thus it incorporates a greater scale of flexibility for local modification accordingly. The central focus of community-based resource management is the empowerment of the local community, especially the ability to manage the resource that the local users and their family closely rely on. Another distinctive characteristic of community-based resource management is the emphasis on the participation of various stakeholders. Other than fishers, there are individuals, groups or organizations who are interested in, involved in or affected by local resource exploitation (boat owners, fish traders, business suppliers, local authorities) should also be considered and incorporated in the CBFM (Tanyang, G., 2001).

5.3 Methodology

5.3.1 Project selection and data collection

The Philippines has the most number of CBFM experience in the world (Pomeroy, R.S., Carlos, M.B., 1997), which could potentially derive fundamental knowledge for the further development of CBFM. During the last three decades, a large number of domestic and foreign-funded projects and programs have implemented community-based management focusing on various resources including forestry, irrigation, and upland areas.

In general, CBFM is a system in which fishers and their communities exercise primary responsibility for stewardship and management, including taking part in decision-making on all aspects of management, such as harvesting, access, compliance, research and marketing (Weber, M.L. & Iudicello, S., 2005). For qualified ones to be included for quantitative analysis in this study, several criteria have to be meet. (1) Projects and programs that targeted on coastal fisheries. (2) The main approach is community-based management. (3) Perception household survey of fisheries management and fishers' livelihood before and after the project or program is required to proceed quantitative analysis. (4) The duration of single project or program must be more than (or equal to) three years for a better presentation of the impacts on both fisheries resource and fisher's livelihood. Because a quasi-experimental with difference-in-difference (DID) method (Abadie, A., 2005; Lechner, M., 2010) was used with a slight tweak for the projects and programs assessment to counteract factors that might have impacts upon certain indicators even there had been no intervention at all. (5) Thus, other than the “treatment group” which included the members of the CBFM, the “control group” which consist of non-members was also required for each project or program.

After searching from various literature including project reports, evaluation documents, publications, scientific journal articles, workshop papers and conference proceedings, 31 site studies in 13 projects and programs across 20 provinces were selected and included in this study (Figure 7 and Table 13). All projects and programs targeted on the coastal fisheries resources, respondents had individually interviewed, for both members and non-members of CBFM (same sample size in two groups) before and after the intervention, about perceptions of community organizing, the well-being of fisheries resources and household livelihood. More indicators were available in some projects or programs, but due to the requirement of common indicators in the meta-analysis, with the average sample size of 93.16 for each site study (including both treatment group and control group), eight common indicators (Table 14) were extracted from all 13 projects and programs. Most chosen projects and programs employed the existing survey framework described by Pomeroy and others (1996), which was also employed by many researchers in studies of the Philippines (Baticados, D.B., Agbayani, R.F., 2000; Katon, B., Pomeroy, R.S., 1999; Maliao, R.J., 2002; Webb, E.L., Maliao, R.J., Siar, S.V., 2004). For other projects and programs did not employ this framework, the data could be standardized accordingly for properly comparison.

Figure 7. Projects and Programs Included in The Meta-Analyses in The Philippines.

Table 13. Projects and Programs Included in The Meta-Analyses in The Philippines.

	Projects & Programs	Funder	Period	Sample Size
1	Central Visayas Regional Project-1 (CVRP-1)	ICLARM	1984-1992	260 (66,64,70,60)
2	Costal Environment Program (CEP)	ICLARM	1993-1996	122 (60, 62)
3	Honda Bay Resource Management Project	ICLARM	1988-1990	54
4	Coastal Resource Management Project (CRMP)	OIDCI, USAID	1982-1986	160 (40, 60, 60)
5	Fisheries Sector Program (FSP)	ADB	1989-1992	442
6	Marine Conservation Project	ICLARM	1989-1993	42
7	Community Fisheries Resource Management Project	IDRCC	1995-1996	42

8	Canadian International Development Agency-Local Government Support Program	ICLARM	1996-2002	60
9	Balayan Bay Integrated Coastal Management Project	WWF, KKP	1990-2005	60
10	Fisheries Co-management Research Project	ICLARM	1988-1998	106
11	Sustaianable Rural District Development Program	SNV	1994-1998	76
12	Fisheries Resource Management Project	ADB	1998-2006	504 (200 in 2 sites, 104 in 1 site)
13	Mindanao Rural Development Program	World Bank	2000-2014	960 (80 in 10 sites, and 88 in 1 site)

Table 14. The Common Indicators Used to Assess the Impacts of CBFM in the Philippines.

Indicators (Mean)	**Definition**
Participation	the level of involvement in fisheries management
Influence	the level of bargaining power over decisions made related to fisheries management
Control	the sense of influence to monitor and regulate the internal use pattern of fisheries
Compliance	the level of conformity of behaviors with prescribed operational rules and regulations
Conflict	competitiveness and promptness in resolving disputes related to fisheries resource use
Access	the level of fair allocation of entering and withdraw fisheries resource
Income	all the revenues earned by a family labor in one year
Resource	the overall well-being of fisheries resource

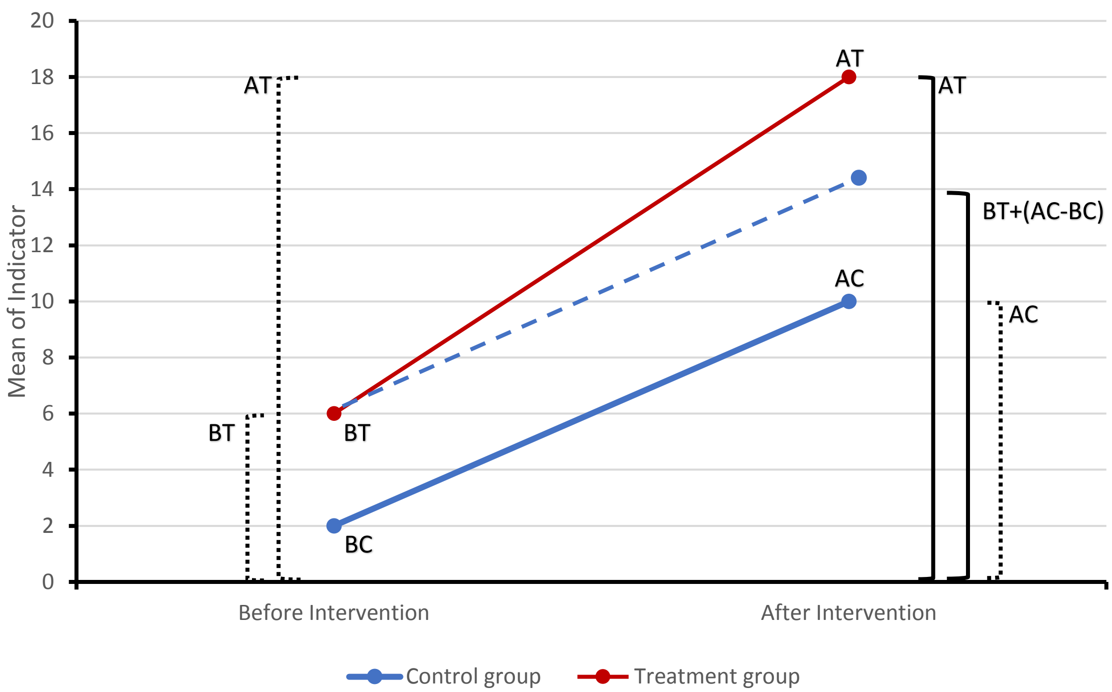
5.3.2 Meta-analysis

It worth mentioning that the meta-analyses (Hedges, L.V., Olkin, I., 1985) applied to this study included (1) generate the summary effect sizes (weighted effect size) of each indicator across all projects and programs for quantifying the directions and magnitudes of the impacts of CBFM (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Card, N.A., 2012), (2) meta-regression for revealing the relation between summary effect sizes and characteristics of fishing households, (3) categorical analysis for identifying the critical years of intervention with a statistical significant increase in summary effect size of each indicator (Kroeker, K.J., Kordas, R.L., Crim, R.N., Singh, G.G., 2010).

5.3.2.1 Effect sizes

The effect sizes used in this study were constructed in the form of response ratio which quantifies the proportionate change as a result of the interventions (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009). The natural logarithm transformation of response ratio was applied in the meta-analyses due to its better statistical performance (Hedges, L.V., Gurevitch, J., Curtis, P.S., 1999). Furthermore, the difference in control group (before and after preception of non-members) was integrated as a modification to the original Response Ratio as the effect sizes (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Card, N.A., 2012; Hedges, L.V., Gurevitch, J., Curtis, P.S., 1999) for limiting the influences that were not caused by projects or programs but affect the indicators. It is noted that the most of the fisheries project reports or project assessment studies in the Southeast Asia did not utilize the information of control group difference (CRMP, 2004; FISH, 2010; Mustafa, M.G., Halls, A.S., 2007). For some that did, which are either a paired-comparison (difference or ratio) of indicators between control group and treatment group both after the project (AT and AC in Figure 8), or for the most case, a paired-comparison of indicators between before and after the project only in treatment group (AT and BT). Neither would estimate the impacts of CBFM projects or programs properly because they are unable to control the factors that would have impacts on the targeting indicators but are not associate with projects’ or programs’ interventions. After the integration of difference in the control group in the calculation of effect sizes for each indicator, uncontrolled factors were quantified as the vertical distance from AC to BC and eliminated by adding to the base-line value of treatment group (BT) in the denominator for the measure of response ratio.

Figure 8. Effect Size Comparison in Project Assessments in The Philippines.



The log response ratio and its standard error were calculated and used to perform all steps in this meta-analysis (Hedges, L.V., Olkin, I., 1985). And the results were converted back to the metric of Response Ratio (RR) for discussion. Thus, the modified Response Ratio (RR) and its logarithm transformation were computed as,

$$Modified\ Response\ Ratio = RR_{ij} = \frac{\overline{X_{t\ ij}^{a}}}{\overline{X_{t\ ij}^{b}} + (\overline{X_{c\ ij}^{a}} - \overline{X_{c\ ij}^{b}})} \tag{5.1}$$

$$\ln\left(RR_{ij}\right) = \ln\left[\frac{\overline{X^{a}_{t\ ij}}}{\overline{X^{b}_{t\ ij}} + \left(\overline{X^{a}_{c\ ij}} - \overline{X^{b}_{c\ ij}}\right)}\right] \tag{5.2}$$

instead of its original form which has no control group integrated as,

$$Response\ Ratio_{i} = \frac{\overline{X^{a}_{t\ i}}}{\overline{X^{b}_{t\ i}}} \tag{5.3}$$

where X is the perception mean of each indicator, t and c indicate the different groups (treatment and control), a and b indicate different time points (after and before the intervention), i and j indicate the number of indicators and the number of projects or programs, respectively. (e.g. $\overline{X^{a}_{t\ ij}}$ stands for the mean of indicator i in the treatment group of projects j after the intervention.)

For obtaining the most precise (minimal variance) estimate of summary effect size for each indicator across all projects and programs, weight (w) was assigned to each program or project for every indicator, which was defined as the inverse of the sample variance (v) of its mean score in each program or project, and calculated as

$$w_{ij} = \frac{1}{v_{ij}} \tag{5.4}$$

The sample variance v_{ij} was estimated by an asymptotic distribution based on the sample size and standard deviation of before and after project survey for both treatment and control groups (Lajeunesse, M.J., 2011) as shown

$$v_{ij} = \left(\frac{1}{\overline{\overline{X^a_{t\ ij}}}}\right)^2 \left[\frac{\left(SD^a_{t\ ij}\right)^2}{N^a_{t\ j}}\right] + C_{ij} \tag{5.5}$$

$$C_{ij} = \left(\frac{1}{\overline{\overline{X^a_{t\ ij}} + \overline{X^a_{c\ ij}} - \overline{X^b_{c\ ij}}}}\right)^2 \left[\frac{\left(SD^b_{t\ ij}\right)^2 + \left(SD^a_{c\ ij}\right)^2 - \left(SD^b_{c\ ij}\right)^2}{N^b_{t\ j}}\right] \tag{5.6}$$

where *N* and *SD* are the sample size and standard deviation of the household survey, respectively, also $N^a_{t\ j} = N^b_{t\ j} = N^a_{c\ j} = N^b_{c\ j}$, *a* and *b* signify the time point of (after and before) project or program, *i* and *j* stand for the specific indicator and which project or program they are in.

When we decide to incorporate a group of studies in a meta-analysis, we assume that the studies have enough in common that it makes sense to synthesize the information, but there is generally no reason to assume that all studies are identical in the sense that the true effect size is the same across all the studies. Because studies will differ in the mixes of participants and in the implementations, it is reasonable to believe that there are different true effects (population variability) underlying different studies (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009). Thus, it would be naturally expected that not every program or project had the exactly same impacts on indicators. In other words, the true effect size of every indicator was not identical across all projects and programs, and any difference was not only due to the sampling deviation (v_{ij}). Thus, the interventions in these independent projects and programs would have differed in ways that would have impacted on the results (indicator means), and therefore the assumption of common effect size (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Lipsey, M.W., Wilson, D.B., 2000) would no longer be appropriate in this meta-analysis. Also, the magnitude of the impacts might fairly be depending on the project characteristics, such as quality of survey design and implementation, cognitive level of respondents, the attitude of respondents towards the project or program. As a matter of fact, we might not be even aware some covariates are related to the size of the effect regardless.

Thus, for better inclusion the population variability, we assumed that there were two parts of variance in each effect size for this study, (1) within-study variance v_{ij} which was caused by sampling error and (2) between-studies variance ${\tau_i}^2$ which reflected true differences (population variability) among effect sizes of same indicator underlying different projects and programs. The random-effects model proposed by DerSimonian and Laird (1986), which included the between-studies variance in addition to the within-study variance to capture the true treatment effect associated with each project or program, fits this scenario much more precisely (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Lipsey, M.W. & Wilson, D.B., 2000; Card, N.A., 2012). In the setting of this study, the total variance in each program or project is the summation of the within-project variance and the between-projects variance as,

$$V_{ij} = v_{ij} + \tau_i^2 \tag{5.7}$$

For the between-study variance, DerSimonian and Laird's method (1986) was employed, and the calculation was shown as,

$$\tau_i^2 = \frac{Q_i - (k-1)}{\sum_{j=1}^{k} w_{ij} - \frac{\sum_{j=1}^{k} {w_{ij}}^2}{\sum_{j=1}^{k} w_{ij}}} \tag{5.8}$$

Q is the statistic that describes the summation of the observed weighted square of the deviation of each effect size from the weighted mean. In another word, it represents the amount of heterogeneity in effect sizes among studies in the meta-analysis (Cochran, 1954; Lipsey, M.W., Wilson, D.B., 2000).

$$Q_i = \sum_{j=1}^{k} w_{ij}\left[\ln(RR_{ij})\right]^2 - \frac{\left[\sum_{j=1}^{k} w_{ij} \ln(RR_{ij})\right]^2}{\sum_{j=1}^{k} w_{ij}} \tag{5.9}$$

where k is the number of projects and programs.

Thus, the Q statistic was used to test the null hypothesis that the means of distribution of an effect size are the same for all projects and programs. Although homogeneity test provided us information about the likelihood of effect sizes being heterogeneous versus homogeneous, it did not provide the magnitude of heterogeneity if it exists. One useful index of heterogeneity in meta-analysis is the I^2 statistic (Higgins, J.P.T., Thompson, S.G., 2002;), which is interpreted conceptually as the percentage of variability among effect sizes of same indicator that exists between studies relative to the total variability (between and within studies) (Huedo-Medina, T.B., Sánchez-Meca, J., Marín-Martínez, F., Botella, J., 2006). But as the nature of meta-analysis across studies, the within-study variance varies from study to study (v_{ij} has two subscripts), so there is no single variance (V_{within}) representing all within-study variances. Thus, I^2 index was estimated according to its conceptual definition (Higgins, J.P.T., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003) as,

$$I_i{}^2 = \frac{\tau_i{}^2}{\tau_i{}^2 + V_{within}} \approx \begin{cases} \frac{Q_i - (k-1)}{Q_i} * 100\% & when\ Q > k-1 \\ 0 & when\ Q \leq k-1 \end{cases} \quad (5.10)$$

I^2 is therefore a readily interpretable index of the magnitude of heterogeneity for each effect size among studies.

Having incorporated both within and between study variabilities in the random-effect model as we calculated both values of v_{ij} and τ_i^2, we were able to compute the total variance for each effect size in each project using equation (5.11). Thereafter, the weight assigned to each study under random-effects model was re-calculated by equation (5.12).

$$V_{ij} = v_{ij} + \tau_i^2 \quad (5.11)$$

$$W_{ij} = \frac{1}{V_{ij}} \quad (5.12)$$

Finally, the summary effect size (weighted mean effect size) and its variance for each indicator across all projects and programs under the random-effects model was calculated in equation (5.13) and (5.14) respectively. Because the integration of the between-studies variability, the weighted effect sizes of all indicators and their confidence intervals were estimated more accurately (Higgins, J.P.T., Thompson, S.G., Spiegelhalter, D.J., 2009; Graham, P.L & Moran J.L., 2012).

$$\overline{\overline{\ln(RR_i)}} = \frac{\sum_{j=1}^{k} W_{ij} \ln(RR_{ij})}{\sum_{j=1}^{k} W_{ij}} \quad (5.13)$$

$$V_{\overline{\overline{\ln(RR_i)}}} = \frac{1}{\sum_{j=1}^{k} W_{ij}} \tag{5.14}$$

Instead of deriving standard error of summary effect size for each indicator by simply taking the square root of its variance of the weighted mean calculated in (5.15), Hedges and others (1999) proposed a more accurate estimate with small sample bias correction as shown,

$$SE_{\overline{\overline{\ln(RR_i)}}} = \sqrt{\frac{1}{\sum_{j=1}^{k} W_j}\left\{1 + 4\sum_{i=1}^{k}\frac{1}{df_i}\left(\frac{W_i}{w_i}\right)^2 \frac{W_i\left[\left(\sum_{j=1}^{k} W_j\right) - W_i\right]}{\left(\sum_{j=1}^{k} W_j\right)^2}\right\}} \tag{5.15}$$

where df_i is the number of degrees of freedom in the ith study.

With standard error estimated, the confidence interval (95%) of weighted mean effect size in random-effect model was calculated as shown,

$$LB_{\overline{\overline{\ln(RR_i)}}} = \overline{\overline{\ln(RR_i)}} - 1.96 * SE_{\overline{\overline{\ln(RR_i)}}} \tag{5.16}$$

$$UB_{\overline{\overline{\ln(RR_i)}}} = \overline{\overline{\ln(RR_i)}} + 1.96 * SE_{\overline{\overline{\ln(RR_i)}}} \tag{5.17}$$

5.3.2.2 Meta-regression and Categorical analysis (subgroup meta-analysis)

To determine whether the effect size of each indicator across projects and programs was consistent, the heterogeneity test using Q statistic was applied, and the I^2 statistic was able to provide the magnitude of that heterogeneity if it existed. Further, meta-regression and categorical analysis were conducted to reveal and quantify the causes for the heterogeneity.

Meta-regressions majorly focused on seeking the relation between the characteristics of fishing households (independent variables) and weighted mean effect sizes (dependent variable) that calculated from the random-effects model. Meta-regression is very similar to the regression in primary studies except that the independent variables were at the level of entire program or project rather than the level of the individual (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Card, N.A., 2012).

Also, the categorical analysis was also carried out for each effect size to determine whether they were impacted differently by the duration of the intervention. Considering the budget constraint that any government, NGO, or private agency has to encounter, the most efficient and effective years of CBFM project or program was rarely discussed in the past. In this study, projects and programs were categorized into two groups with multiple times by the length of CBFM intervention of each project or program (Table 13). For example, the two groups can be differed by more than five years and less than five years of CBFM. Because there were 13 different durations for all projects or programs included in this study, 13 times of categorization were conducted (26 groups), and categorical analyses were then carried out between weighted effect size in two groups for each indicator using the Q_{btw} statistic as shown below, it used to test the null hypothesis that the weighted mean of distribution of effect sizes are the same for two groups.

$$Q_{btw} = \sum_{g=1}^{c} \sum_{p=1}^{n_g} w_{pg} \left[\ln(RR_{pg})\right]^2 - \frac{\left[\sum_{p=1}^{n_g} w_{pg} \ln(RR_{pg})\right]^2}{\sum_{p=1}^{n_g} w_{pg}} \tag{5.18}$$

where g is the number of groups, n_g is the number of projects and programs in the group g, $\ln(RR_{pg})$ stands for the effect size of pth program or project in the group g, w_{pg} stands for the weight of the effect size of pth program or project in the group g.

The significance of both Q_i and Q_{btw} were tested against the χ^2 distribution with $k-1$, and $g-1$ degrees of freedom respectively. All meta-analyses were conducted using random-effects model in Comprehensive Meta-Analysis (CMA) version V3.3 (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009).

5.4 Results

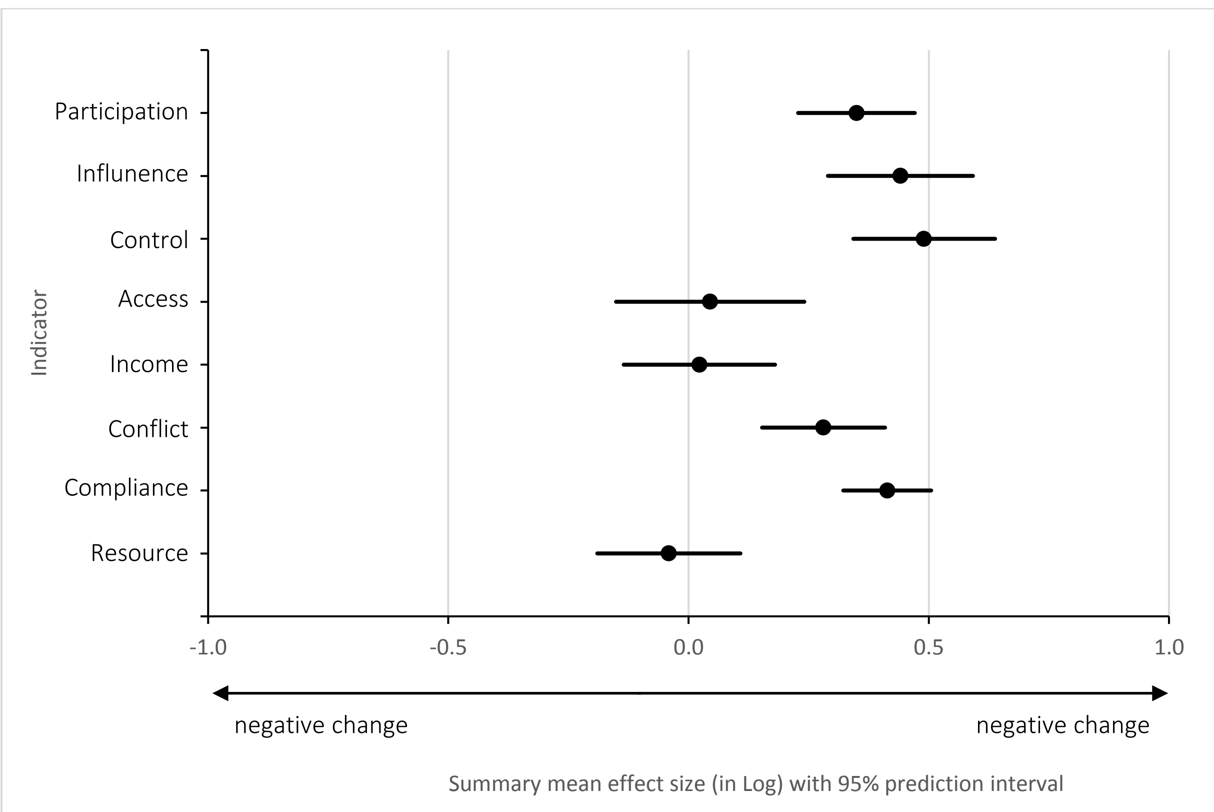
By extraction of eight common indicators in 13 projects and programs, the effect size of CBFM for each indicator was calculated in the form of response ratio (*RR*). Rather than focusing on the p-value of each study, it is critical shifting to the summary effect size of each indicator across all projects and programs (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Card, N.A., 2012). Furthermore, with summary effect size calculated for each indicator, the inconsistency of the effect sizes was detected. This inconsistency quantitatively verified the site-specific nature of CBFM (Israel, D.C., 2001), which indicated that there were some true-effect differences (population variability) between projects or programs other than differences caused by sampling error (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Card, N.A., 2012). Also, the results of categorical analyses and meta-regressions were reported by presenting how the true-effect difference impacts each effect size and the relation between summary effect sizes and characteristics of the fishing households.

5.4.1 Effect sizes

Nearly all summary effect sizes of indicators in CBFM projects and programs selected in this study showed a fairly positive change in the Philippines (Figure 9). *Participation*

($\overline{\overline{RR}} = 1.42, PI = 1.26 - 1.60, p < 0.001$), *influence* ($\overline{\overline{RR}} = 1.55, PI = 1.34 - 1.81, p < 0.001$), *control* ($\overline{\overline{RR}} = 1.63, PI = 1.41 - 1.89, p < 0.001$), *compliance* ($\overline{\overline{RR}} = 1.51, PI = 1.38 - 1.66, p < 0.001$), *conflict* ($\overline{\overline{RR}} = 1.32, PI = 1.17 - 1.51, p < 0.001$), *access* ($\overline{\overline{RR}} = 1.05, PI = 0.86 - 1.27, p = 0.65$) and *income* ($\overline{\overline{RR}} = 1.02, PI = 0.87 - 1.20, p = 0.776$) were all perceived to increase through CBFM projects and programs. While the summary effect size of *resource* ($\overline{\overline{RR}} = 0.96, PI = 0.83 - 1.11, p = 0.588$) revealed a negative change for all included projects and programs.

Figure 9. Summary Effect Sizes (In Log) of CBFM Projects and Programs in The Philippines Based on Eight Indicators.



5.4.2 Meta-regression

Although the magnitudes of summary effects were estimated by a weighted average of same effect size in every project, eight effect sizes were discovered of being quite inconsistent across projects and programs. Having the results of heterogeneity test using Q statistic (Table 15), almost all effect sizes (except *compliance*) were discovered to be inconsistent across projects and programs with statistical significance. Also, the magnitude of true differences in effect sizes was captured by I^2 statistic, which represents the extent of overlap of prediction intervals and commonly be severed as a measure of inconsistency of effect sizes among projects and programs (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Card, N.A., 2012; Higgins, J.P.T., Thompson, S.G., Deeks, JJ., Altman, D. G., 2003). It is noted that this true difference (population variability) in effect sizes will not fade out when there is a boost in sample size. In this study, the I^2 statistic indicated that, on average, 71 percent of observed variances were true-effect difference for each effect size between projects and programs rather than the spurious sampling errors.

Table 15. Heterogeneity Test of Effect Sizes in The Meta-Analysis in The Philippines.

Indicator	**Q-value**	**P-value**	***df*.(Q)**	**I-squared**
Participation	53.78	0.000	30	68.39
Influence	87.01	0.000	30	80.46
Control	53.31	0.000	30	69.99
Compliance	26.91	0.059	30	36.82
Conflict	40.72	0.001	30	60.71
Access	98.46	0.000	30	83.75
Income	128.65	0.000	30	86.01
Resource	114.10	0.000	30	84.22

Table 16. Characteristics of Fishing Households in The Philippines.

Independent Variable	**Definition**
Household Size	The number of workforce in a household, including the ones who are working outside the village.
Residing Year	The number of years that respondent had resided in the village before the implementation of CBFM projects or programs.
Education	The number of years of formal schooling.
Duration	The number of years of implementation of CBFM program or project.

Such high level of heterogeneity originated from true differences deserved a further investigation on the relation between each effect size (dependent variable) and the characteristics of fishing household (independent variable). Meta-regression was applied to assess the relation between moderators (independent variables) and effect size (dependent variable) using a random-effects model in the meta-analysis (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009; Card, N.A., 2012).

Let

$$\mathbf{Y}_{\boldsymbol{i}} = \begin{bmatrix} Ln(RR_{i1}) \\ \vdots \\ Ln\left(RR_{ij}\right) \end{bmatrix}, \qquad \mathbf{X} = \begin{bmatrix} 1 & HS_1 & RY_1 & ED_1 & DU_1 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & HS_j & RY_j & ED_j & DU_j \end{bmatrix}, \qquad \beta_i = \begin{bmatrix} \alpha_i \\ \beta_{i1} \\ \beta_{i2} \\ \beta_{i3} \\ \beta_{i4} \end{bmatrix},$$

$$\mathbf{u}_{\boldsymbol{i}} = \begin{bmatrix} u_{i1} \\ \vdots \\ u_{ij} \end{bmatrix}$$

i is the number of effect size ($i = 1, \dots, 8$); j is the number of site-study ($j = 1, \dots, 31$). *HS*, *RY*, *ED*, and *DU* are the sample mean of the indicators of Household Size, Residing Year, Education, and Duration, respectively. $Ln(RR_{ij})$ is the effect size of ith indicator in site-study *j*.

There were four characteristics (Table 16) of fishing household that were available in all selected projects and programs. We assumed the linear relation between the effect size of each indicator as an endogenous variable and four characteristics of the fishing household as exogenous variables. Thus, multiple linear regression models with Ordinary Least Square estimation was used in this study to seek the relation between each effect size, $Ln(RR_{ij})$, and four characteristics of fishing household as shown,

$$\mathbf{Y}_{\boldsymbol{i}} = \mathbf{X} * \beta_i + \mathbf{u}_{\boldsymbol{i}} \tag{5.19}$$

The results of meta-regression were shown in Table 17. Q_{model} was used to diagnose if the model properly explains the dependent variable. It used to test the null hypothesis that none of the covariates is related to effect size against the chi-squared distribution with degrees of freedom equal to the number of explanatory variable (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009). Thus, the significance (at 95% level) of Q_{model} statistic means that the relation between explanatory variables and effect size of treatment is stronger that we would expect by chance. For the test of goodness of fit, the $Q_{resid.}$ statistic can be used to address the question of whether there is heterogeneity that is not explained by the explanatory variables. It was used to test the null hypothesis that unexplained variance is zero, which indicates all heterogeneity is explained by the covariates.

With the inspection of the significance of both Q_{model} and $Q_{\mathrm{resid.}}$ at 95% confidence level in the meta-regression, it is noted that other than the effect size of *access* and *resource*, all other six effect sizes were well supported by the selected characteristics of fishing household. Almost all effect sizes had a positive coefficient with education, household size and duration of program or project. More specific, for the relations that were statistically significant, the effect size of *participation* would increase 16 percent, 5 percent, and 3 percent by the marginal increase in education, household size, and duration of CBFM program or project, respectively. The effect size of influence would increase 16 percent, 7 percent, and 2 percent with the marginal increase in education, household size, and duration of CBFM program or project, respectively. The effect size of *control* would increase 6 percent and 4 percent with the marginal increase in education and duration. The effect sizes of *compliance* would increase 2 percent, 3 percent, and 3 percent with the marginal increase in education, household size, and duration, respectively. The effect sizes of *conflict* would increase 12 percent and 1 percent with the marginal increase in education and duration. The effect sizes of *income* would increase 5 percent, 4 percent with the marginal increase in household size and duration. While, the relations between the effect sizes of *access* and *resource* and all four household characteristics (residing year, education, household size, and duration) was not statistically significant. Also, the statistically significant of $Q_{\mathrm{resid.}}$ for these two effect sizes indicated that there was significant amount of unexplained variations in the residual and these two effect sizes were not well supported by the given characteristics of fishing the household. Although there were two explanatory variables (education, duration) that has positive coefficients with statistically significance, the statistically significant $Q_{\text{resid.}}$ of the effect size of *conflict* revealed that some variations were not full explained by this linear model.

Table 17. Meta-Regression Analyses Between Characteristics of Fishing Households and Performance Indicators.

	Residing year	Education	Household size	Duration	Q_{model}-*Sig.*	$Q_{resid.}$-*Sig.*
Participation	-0.01 (0.02)	0.16 (0.08) **	0.05 (0.02) ***	0.03 (0.02) **	0.000	0.250
Influence	0.05 (0.02) **	0.16 (0.08) **	0.07 (0.02) **	0.02 (0.02)	0.000	0.091
Control	0.00 (0.02)	0.06 (0.03) ***	0.02 (0.02)	0.04 (0.02) **	0.011	0.362
Compliance	-0.00 (0.02)	0.20 (0.08) ***	0.03 (0.02) **	0.03 (0.02) **	0.000	0.537
Conflict	0.00 (0.02)	0.12 (0.05) **	0.04 (0.02)	0.01 (0.02) **	0.027	0.022
Access	-0.03 (0.02)	-0.14 (0.14)	0.03 (0.03)	0.03 (0.02)	0.606	0.000
Income	-0.01 (0.02)	-0.07 (0.08)	0.05 (0.02) **	0.04 (0.02) **	0.039	0.141
Resource	-0.01 (0.03)	0.03 (0.16)	0.06 (0.04)	0.03 (0.03)	0.557	0.000

Statistical significance is noted by two asterisks (**) at the 5% level, and three asterisks (***) at the 1% level.

5.4.3 Categorical analysis (Subgroup meta-analysis)

The results of meta-regression presented a positive coefficient of a duration associated with all effect sizes in which five were statistically significant. This general positive relation indicated a better performance of indicators (larger effect size) when a longer duration of CBFM was in place (especially to the ones with statistically significant). However, any project or program has its budget constraint even in the planning stage. Thus, how many years of intervention would have a statistically significant improvement on target indicators becomes fundamental for fishing households, donors of program or project, and the development department of local government. Categorical analysis was carried out to identify the "threshold year" of effect sizes that showed a statistically significant relation with duration of projects and programs in the meta-regression, including *participation*, *control*, *compliance*, and *income*. It worth noting that the median and the mean of duration of CBFM projects and programs included in this study was 9 and 9.73, respectively. The significance of Q_{btw} was tested against the chi-square distribution with degree of freedom of one for each effect size between groups which differed by duration of projects and programs.

For the effect sizes that have statistically significant relations with duration of CBFM from the meta-regression, the threshold year of improvement in effect size with statistically significant was considerably varied (Table 18). The effect size of *participation* and *control* were shown to be improved with statistically significance when the duration of CBFM was at least over (or equal) eight years. The effect size of *compliance* needed two more years to be improved with statistical significance. While the effect size of *income* needed a considerably longer implementation time (15 years) of CBFM project or program for achieving improvement with statistical significance. For the effect sizes that did not have statistically significant relations with duration of CBFM from the meta-regression, the threshold year of improvement in effect size with statistically significance was also revealed by categorical analysis (except for *conflict*). The effect size of *access* was shown to be improved with statistically significance when the duration of CBFM was at least over (or equal) six years. The effect size of *influence* needed four more years to be improved statistically significant. The effect size of *resource* needed an extra four years (14 years) of implementation of CBFM for achieving improvement with statistical significance.

Table 18. The Statistical Significance of The Difference in Subgroup Means of Effect Size.

Groups (years of duration)	$Q_{btw} - Statistic$ *Participation*	Control	Compliance	Income	Conflict	Access	Influence	Resource
<2 and ≥2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<4 and ≥4	0.86	1.35	0.63	0.05	0.26	0.10	1.44	0.49
<5 and ≥5	0.08	0.00	0.00	1.28	0.51	1.25	0.05	1.53
<6 and ≥6	0.16	0.36	0.10	1.62	1.43	4.20**	0.12	3.15
<7 and ≥7	0.00	0.24	0.56	0.45	2.68	0.05	0.04	0.64
<8 and ≥8	5.13**	3.99**	3.28	0.00	0.00	0.01	1.07	0.05
<9 and ≥9	3.37	1.54	0.94	0.05	0.76	0.20	1.03	0.00
<10 and ≥10	1.83	6.58**	6.72**	0.04	0.04	0.13	7.83**	0.42
<11 and ≥11	1.13	4.88**	3.20	0.23	1.48	0.12	3.80	1.45
<12 and ≥12	0.47	3.78	3.58	0.29	0.86	1.27	2.76	0.99
<14 and ≥14	0.43	6.44**	2.55	1.60	2.42	0.40	0.99	4.64**
<15 and ≥15	2.39	0.64	0.16	6.52**	2.14	0.12	2.58	2.99
<21 and ≥21	1.96	0.39	1.88	0.34	0.04	0.01	0.37	1.73

Statistical significance is noted by two asterisks ($**$) at the 5% level.

5.5 Discussion

Overall, the summary effects of CBFM in the Philippines were considered as positive for all indicators included in this study. However, the magnitude and heterogeneity, most influential factors, and the onset time of each summary effect size were revealed quite differently. All summary effect sizes were discussed below in the dimensions of equity and sustainability.

5.5.1 Equity dimension (*participation, influence, control, access, income*)

The summary effect sizes of *participation* ($\overline{\overline{RR}} = 1.42, CI = 1.26 - 1.60$), *influence* ($\overline{\overline{RR}} = 1.55, CI = 1.34 - 1.81$), *control* ($\overline{\overline{RR}} = 1.63, CI = 1.41 - 1.89$), *access* ($\overline{\overline{RR}} = 1.05, CI = 0.86 - 1.27$), and *income* ($\overline{\overline{RR}} = 1.02, CI = 0.87 - 1.20$) were all have a mean response ratio over 1, which indicated that the fisheries under CBFM had a better performance on these five indicators than the fisheries under control group in the Philippines. Other than the effect sizes of *access* and *income*, other three effect sizes were statistically significant. Just like Viswanathan and others (2003) argued that equity is one distinct advantage in the CBFM. The results of this study verified this argument quantitatively and revealed sizeable magnitude (33% increase in weighted mean effect size) of equity improvement in fishing households in the Philippines by CBFM.

In the meantime, the high level of heterogeneity (I^2 was 77.72 on average) was also discovered for the equity effect sizes, which indicated the effect sizes of equity were not consistent perceived across sites in different projects and programs. In other words, there were some true differences underlying the various aspects of the CBFM sites and CBFM program or project, such as diverse quality of survey design and implementation, location of community, cognitive level of respondents, the attitude of respondents towards the project or program, and even the duration of program or project. This high degree of heterogeneity was also stated in several studies as the site-specific nature of CBFM (Israel, D.C., 2001; Weber, M.L., Iudicello, S., 2005; Lobe, K., Berkes, F., 2004). The effect size of *access* ($I^2 = 83.75$), *resource* ($I^2 = 84.22$) and *income* ($I^2 = 86.01$) revealed considerable heterogeneity, which are the reflection of open-access nature of the marine fisheries and the highly dynamic and site-specific characteristic of fisheries resources. More causes of heterogeneity were investigated in meta-regression below.

From the results of meta-regression, education stood out as an influential factor (Dohrn, C.L., 2013; Nickerson-Tietze, D.J., 2010; Pomeroy, R.S., Rivera-Guieb, R., 2005) to the effect size of *participation*, *influence*, and *control* with 16 percent, 16 percent, and 6 percent contribution, respectively, when every one extra year of education is added. The Household size contributed to the effect sizes of *participation* (5%), *influence* (7%), and *income* (5%) with its marginal gain. In small-scale fishing communities, fishing-crew members and other fisheries-related worker are often recruited more often by their important social ties in the community, rather than by their particular skills, experience, or labor price (McGoodwin, J.R., 2001). Thus, bigger household size tended to have more family relationships in the community. Therefore the household members perceived to have a higher level of involvement and bargaining power in their community. The positive relation between household size and income was not only because more workforce could generate more revenue but also due to the prevailing back-feeding tradition in Asia, which is characterized by sending money back home from members who are working outside the village (Tietze, U., Siar, S.V., Marmulla, G., Anrooy, R.V., 2007).

The duration of CBFM was another important factor explaining the heterogeneity in effect sizes across projects and programs. With 3 percent, 4 percent, and 4 percent contribution to the effect sizes of *participation*, *control*, and *income* respectively, it was favorable to have a longer period of implementation of CBFM for equity improvement. Longer duration of projects or programs enables the better understanding of both objectives and corresponding measures. As the fundamental characteristics of CBFM indicates, fishers are the ones exercise primary responsibility for stewardship and management, including taking part in decision-making on all aspects of management, such as access, harvest, and monitoring (Thompson, P.M., 1999; Weber Michael L., Iudicello Suzanne, 2005; Yamamoto, T., 1996). Thus, with a longer and stable management plan in place, fishers have more willingness to make their voice heard and got involved in managing resource on which they and their families depend the most.

However, with the budget constraint that every government or NGO or any other private agency has to considered, longer is not always a favorable word to them. Different objectives might require a different length of implementation. By employing categorical analysis to the selected projects and programs, a certain length of time (threshold-year) was identified for each effect size to reveal a difference with statistical significance. The threshold-years for the effect sizes of *participation*, *control*, *access*, and *income* were revealed differently. The improvement on *participation* and *control* required at least eight years of implementation of CBFM. The effect size of *control* showed four threshold-years, and eight years of CBFM was the shortest one with smallest but significant improvement, while ten years was the one with largest significant improvement. The threshold-years for *access* and *income* were perceived differently. The effect size of *access* had the shortest threshold-year (6 years) out of all effect sizes. CBFM emphasizes self-initiated management where the fishers take responsibility for some functions, collective decision on the distribution of resource, entering and withdraw is one of them. Thus, an improvement in access could be theoretically achieved fairly quickly after the establishment of CBFM if ideal compliance is presented (Weber, M.L., Iudicello, S., 2005). Moreover, because of the management complement local cultural value, the incentives to respect and support the rules are self-imposed, and are seen as individually and mutually beneficial (Dey, M.M., Kanagaratnam, U., 2007). To the contrary, the threshold year for the effect size of i*ncome* was discovered as the longest in all effect sizes, with the statistically significant difference appeared in 15 years of CBFM. This considerable long time-span for the improvement on effect size of *income* has not only to do with the longer recovery time of resource which will be discussed in sustainability dimension, but also indicating the difficulty for establishment of income-generation alternatives for this specific sector (Berkes,F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R.S., 2001; FAO, 2005). It is important to note that Pomeroy and others (1996) suggest that fishers like their occupation and would not necessarily change to another one. Crawford (2002) also indicated that willingness to change occupation was much lower among poorer, younger, less educated, and less successful fishers due to the risks of new activities. Thus, the development of supplemental rather than alternative occupations, encouraging a shift from full-time fishers to part-time fishers would be a more realistic goal.

5.5.2 Sustainability dimension (*conflict, compliance, resource*)

The summary effect sizes of *conflict* ($\overline{\overline{RR}} = 1.32, PI = 1.17 - 1.51$) and *compliance* ($\overline{\overline{RR}} = 1.51, PI = 1.38 - 1.66$) were perceived to be greater than one, while the summary effect size of *resource* ($\overline{\overline{RR}} = 0.96, PI = 0.83 - 1.11$) was perceived to be less than one after implementation of CBFM in the Philippines for the selected projects and programs. Except for the effect size of *resource*, other two effect sizes were perceived statistically significant. A possible explanation for the *resource*, given the positive *conflict* and *compliance*, is that the fish populations have been recovering at a very slow pace from a pretty bad point (Webb, E.L., Maliao, R.J., Siar, S.V., 2004). Giving more than 90 percent of fishing grounds have been fished down to 5 to 30 percent in the Philippines (Stobutzki, I.C., Silvestre, G.T., Talib, A.A., Krongprom, A., Supongpan, M., Khemakorn, P., 2006; Tupper, M., Asif, F., Garces, L.R., Pido, M.D., 2015; Webb, E.L., Maliao, R.J., Siar, S.V., 2004), this is fairly reasonable explanation. In addition, due to the open-access of the marine fisheries, illegal fishing and destructive fishing were not completed precluded from the outsiders (IFAD, ANGOC, IIRR, 2001; Van Mulekom, L.V. & Tria, E.C., 1997; FAO, SPC, 2010). The potential competitiveness between community organized fishers and outsiders could lead to fluctuations on both effect size of *resource* and *conflict* (Pomeroy, R.S., Parks, J., Pollnac, R., Campson, T., Genio, E., Marlessy, C., Holle, E., Pido, M., Nissapa, A., Boromthanarat, S., Thu Hue, N., 2007), which were reflected by sizable inconsistency across sties in different projects and programs, with 84 percent and 64 percent of variation originated from true differences.

By inspection through meta-regression, education was discovered to be a very influential factor to *compliance* and *conflict*. The effect size of *compliance* and *conflict* increase 20 percent and 12 percent when one more year of education is gained. The meta-regression reported that education, household size, and duration contributed 20 percent, 3 percent, and 3 percent to the effect size of *compliance*, which further emphasized the crucial role of fishers' education, not only to improve equity among fishers but also facilities the sustainability of the CBFM (Crawford, B., 2002). With the statistically significant positive relation between effect size of *compliance* and the *duration*, a categorical analysis was conducted and revealed that the threshold years of the effect size of *compliance* was 10.

The threshold-year for effect size of *compliance* is comparable to the effect sizes of *participation* (8 years) and *control* (8 years) for similar reasons as mentioned before. Also, it is noted that the improvement with statistical significance in *compliance* happened later than the threshold-years of *participation* and *control*. Higher *participation* and *influence* indicated more acceptance and approval of CBFM by the fishing household (Viswanathan, KK., Nilsen, J.R., Degnbol, P., Ahmed, M., Hara, M., Nik Mustapha, R.A., 2003). Also, one of the benefits of the self-managing approach is higher efficiency and effectiveness in enforcement and monitoring process than bureaucracies do (Dey, M.M., Kanagaratnam, U., 2007). Together with these two, the high level of conformity of behaviors with prescribed rules and regulations was expected.

For the effect size of the *resource*, although the regression model did not well explain the variation of *resource* based on selected covariates, duration was still suspicious of having a relation with the effect size of the *resource*. Thus, a categorical analysis was employed to seek if any relation exists. The difference between the duration of CBFM and weighted effect size of *resource* was statistically significant at 14 years of CBFM. This considerable long period of intervention is in coordination with the effect size of *income* which also needs a comparable 15 years of CBFM for a statistically significant improvement as we mentioned in the equity dimension. It is noted some projects and programs reported a fish abundance increase in the relatively shorter period than the results of this study (SUMACORE, 2010; USAID, 2010). The discrepancy was due to two major differences, (1) application of control group difference, and (2) the different measurement. As mentioned in the methodology, this study incorporated a quasi-experimental with difference in difference (DID) method, which incorporated control groups difference to counteract factors that might have impacts upon certain indicators by factors that beyond the influence of interventions. For the second difference, some studies use biomass for measurement which was relatively quicker and easier to be recovered comparing to the "value fish" that either be served as direct food consumption or as merchandise for income generation for the fishing communities.

Pomeroy (1995) argued that fishing communities, under certain conditions, can regulate access and enforce rules through community institutions and social practices to use fisheries resources sustainably. Recent studies on coastal fisheries management in the Philippines also argued that the approach of community-based fisheries is capable of removing the competitive spirits out of the fisheries and focusing the community as a whole on practicing fisheries in a sustainable manner (Graham, J., Charles, A., Bull, A. 2006; The WorldFish Center, 2011).

5.6 Conclusions

The overall outcomes of meta-analyses in this study indicate a positive impact of CBFM, on the equity of both involvements in management and benefit sharing as well as sustainable management of fisheries resources in the Philippines by investigating the effect sizes of eight indicators. The positive summary effect sizes of *participation*, *influence*, *control*, *access*, and *income* conjunctly portrayed an improved equity of the fishing community by implementing CBFM. The positive summary effect sizes of *compliance* and *conflict* indicated an affirmative community and therefore a sustainable management. While the negative summary effect size of *resource* revealed the difficulties in recovering fish abundance in relatively short period. For further improvement of CBFM, based on the meta-regression analysis, the education was found to be the largest contributor to *Compliance* (20%), *Participation* (16%), *Influence* (16%), *Conflict* (12%), and *Control* (6%), which had the biggest impact on the organization and management of fishing community. The issues of community-based management are generally complex and there is a need to promote environmental awareness in the community and to develop people's capacity to actively participate in the CBFM. Environmental education is a critical ingredient in the transformation of community members into active partners in CBFM. Environmental education empowers people and improves their environmental awareness through knowledge. Also, the performance of CBFM or any other fisheries management projects or programs depend the most on the implementation process, which has a close relation with the rationality degree of the fishers. A better organized fishing community would be more efficient and effective in seeking alternative livelihood, which is critical for lowering the dependency on the fisheries resources. Thus, the environmental education by any form of knowledge attainment facility should have a higher priority when future CBFM programs or projects are considered. (Deepananda, K.H.M.A., Amarasinghe, U.S., Jayasinghe-Mudalige, U.K., 2015; Sultana, P., Thompson, P.M., 2007).

As for the duration of implementation, different effect sizes were revealed a different length of CBFM for their sensible improvement. In the equity dimension, the effect size of *access* showed statistically significant improvement at six years of implementation of CBFM, which was the shortest duration of all eight effect sizes. Ten years of implementation was discovered as the duration with perceivable equity improvement because it provided a statistically significant increase in all effect sizes in this dimension except *income*. In the sustainability dimension, ten years was also found to be a duration with statistically significant improvement, except for *resource*. For both *resource* and *income*, 14 and 15 years of CBFM showed statistically significant improvement, respectively. The considerable longer time span than other effect sizes should not be surprised due to the status of heavily overexploited fisheries resource and high level of dependence for the fishing communities in the Philippines. In contrary to the 5-year-plan proposed by most donors for fisheries projects and programs, this study discovered a considerable longer implementation for performance improvement. Even for the management aspects such as *participation*, *influence*, *compliance*, *conflict*, *access*, and *control*, which are usually expected to show a quicker improvement after implementation of CBFM, five-year is far less enough to be able to achieve statistically significant improvement, let alone the management that will sustain after the end of the project or program. The *resource* and *income* should expect the even longer implementation of CBFM or multiple phases of CBFM to be able to achieve statistically significant improvement.

In the perspective of resource users, CBFM was prompted by their dependence on fishery resource for livelihood, recognition of resource management issues from local fishers, and participatory management using collective knowledge and decision from resource stakeholders. The intimate knowledge and local specific experiences make their participation in resource management unique and efficient. In the perspective of fisheries resource, the tangible benefits in the form of higher fish catch and therefore higher income and more sustainable livelihood further encourage a better rule compliance and further elimination of illegal and destructive fishing practice over time.

This study was not an exhausted performance evaluation due to the limited indicators and project availability, but it does shed some lights on the impacts of CBFM on equity of management involvement and benefit sharing as well as sustainable management of fisheries resource. This study also provided a first attempt to evaluate and analyze the effect sizes of CBFM by utilizing meta-analysis (random-effects model) and meta-regression, which is relevant to improving the quality of livelihood among poor rural people, as well as to facilitating poverty alleviation. Rather than narrative synthesis, which suffers from the subjectivity of drawing a conclusion from various studies, meta-analysis is capable of statistically synthesizing the data to discover the direction and magnitude of the summary effect of CBFM across projects and programs, in a transparent, objective, and replicable manner (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009). Moreover, the results could be used as relevant information for institutions and donors who want to apply community-based fisheries for rural development and fisheries resource management.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This final chapter serves to recap the major results and findings from the three essays. The results of all meta-analyses are summarized in the initial section. It includes the summary of results and conclusions draw from each essay and recommendation for further plan and implementation of CBFM. In the second section, a discussion of the application of meta-analysis in fisheries management is offered regarding its advantages and limitations.

6.1 Summary

Cambodia

The overall outcomes of meta-analyses in the Cambodian study indicate a mixed view of how the effects of CBFM on the livelihood of fishing communities and sustainable management of fisheries resources in Cambodia by investigating six indicators. The positive summary effect size of *income*, *household expenditure*, *asset value*, and *fishing gear* conjunctly portrayed an improved livelihood of the fishing community with 16%, 75%, 70%, 82% increase in their mean by implementing CBFM. The negative (less than one) effect size of *land size* (57% decrease in mean) revealed the difficulties in improving social inequality and the ownership confusion caused by the introduction of a modern legal system by the government and the customary law that prevails in most rural areas. The effect size of *fish catch* by implementing CBFM, although still negative (61% decrease in mean), revealed a small but statistically significant improvement (37% increase in mean) in longer CBFM through categorical analysis.

Bangladesh

The overall outcomes of meta-analyses in the study of Bangladesh revealed positive impacts of CBFM on the fisher's livelihood, sustainable fisheries management, and fisher empowerment by investigating the effect sizes of 13 common indicators. The positive summary effect sizes of *Participation*, *Influence*, *Conflict*, and *Leadership* conjunctly indicated that fishers under CBFM are now more organized in terms of their willingness to attend the meetings regarding fisheries management as well as other community affairs and a less colliding, more harmonious manner of fishing activities and community atmosphere. The positive summary effect sizes of *Knowledge*, *Information*, and *Credit* revealed that the level of fishers' empowerment in inland fishery management in Bangladesh had improved significantly under the CBFM. Although the summary effect size of *Compliance* and *Fish Catch* showed no statistically significant, the effect size of each of them showed statistically significant difference between two types of waterbodies. The *beels* with entry restriction had better performance in most indicators, including *Fish Catch* and *Compliance*, but with a higher operation cost. The rivers had a better performance in *Fishing Income* and *Employment* with its open access, but the lower *non-fishing Income* revealed its deeper dependency on the fisheries resource and less sustainability. The competitiveness from outsiders and higher vulnerability from rainy season also differed the effect sizes of *Participation*, *Influence*, and *Conflict* between household fishing in beels and rivers.

Philippines

The overall outcomes of meta-analyses in the study of Philippines indicated a positive impact of CBFM, on the equity of both involvements in management and benefit sharing as well as sustainable management of fisheries resources by investigating the effect sizes of eight indicators. The positive summary effect sizes of *participation*, *influence*, *control*, *access*, and *income* conjunctly portrayed an improved equity of the fishing community by implementing CBFM. The positive summary effect sizes of *compliance* and *conflict* indicated an affirmative community and therefore a sustainable management. While the negative summary effect size of *resource* revealed the difficulties in recovering fish abundance in relatively short period. For further improvement of CBFM, investment in education will be most effective manner for most of the effect sizes (Deepananda, K.H.M.A., Amarasinghe, U.S., Jayasinghe-Mudalige, U.K., 2015; Sultana, P., Thompson, P.M., 2007). As for the duration of implementation, different effect sizes were revealed a different length of CBFM for their sensible improvement. In the equity dimension, the effect size of *access* showed statistically significant improvement at six years of implementation of CBFM, which was the shortest duration of all eight effect sizes. Ten years of implementation was discovered as the duration with perceivable equity improvement because it provided a statistically significant increase in all effect sizes in this dimension except *income*. In the sustainability dimension, ten years was also found to be a duration with statistically significant improvement, except for *resource*. For both *resource* and *income*, 14 and 15 years of CBFM showed statistically significant improvement, respectively.

Overall, from the studies of three Asian countries, CBFM was able to achieve a better organized fishing community, an improved livelihood, and contribute to the sustainable fisheries. Although it does not directly target on the fisheries resource, it emphasizes the capability as well as the responsibility of individual fisher and centering organizing fishing community and collective decision-making. It is inherently evolutionary, participatory, and local-specific with the consideration of the technical, socioeconomic, cultural and environmental elements integrated, which all have a significant impact on the local community. With less colliding, more harmonious manner of fishing activities and community atmosphere that CBFM brought, the competitiveness of fisheries was eased up, which greatly lower the consequent violence and vulnerability of fishers' livelihood.

However, the nature of open access of small-scale fisheries was not fully tackled by CBFM. The better organized fishing community did restrict access by passing rules and regulations by collective decision for all the members, but it could be violated and weakened by outsiders. Thus, access control is still needed to facilitate the implementation of CBFM, but it must be introduced along with the alternative livelihood. Otherwise, pure access blocking can only intense the conflict between fishers and vastly jeopardize the effects of CBFM. Therefore, CBFM is essentially the first step of sustaining fisheries resource and improving fishers' livelihood. It places a solid foundation for livelihood diversification and distribution of resource benefits and management arrangements among stakeholders. With the addition of access control and stock recovery programs, a holistic and multi-disciplinary approach is more likely to be forged, which is more flexible and appropriate to meet the local needs in different regions or countries.

6.2 Application of Meta-analysis

Meta-analysis is a study which collecting and selecting previous studies that qualified certain criteria, coding and analyzing data extracted from nominees, and finally providing suggestions to targeted decision-makers. Such studies bring together individual results from underlying studies in order to determine if and where broader generalizations can be made than would have been possible by individual case studies. Therefore, meta-analysis is the new research by synthesizing and analyzing previous researches with the distinctive merits, which include 1) directly focused on the direction and magnitude of the effect caused by interventions; 2) examines pattern of evidence across all studies by constructing proper effect sizes; 3) investigate any perceivable effect to check the degree of consistency of the underlying effect sizes; 4) investigate and identify the categorical pattern, and test whether variation among studies in effect size is associated with true differences in study methods or participants by applying categorical analysis. It worth mentioning that the meta-analyses that been used in this research are primarily the meta-analyses of effect size. That is, analyses where each study yields an estimate of same statistics (standardized mean difference, response ratio, etc.) and the goal is to analyze the dispersion in these effects and the seeking the cause and magnitude, if there is any, of the heterogeneity in effect sizes. The meta-analyses in this research directly target on the magnitude and the heterogeneity analysis of effect sizes, and the relation between the effect sizes and characteristics of fishing communities. As of to date, meta-analysis has been applied to various research topics. Although its rare application in the fishery, or resource economics in general, the similarities in design and practice between the classic applications in psychology and other experimental sciences and the local/regional pilot programs of fisheries carried out by governments and NGOs make meta-analysis a very promising and relevant approach here.

This research provided a first attempt to evaluate and analyze the effect sizes of CBFM by utilizing meta-analysis (random-effects model) and meta-regression, which is relevant to improving the quality of livelihood among poor rural people, as well as to facilitating poverty alleviation. Due to the variation of implementation location and projects/programs initiator, it is more realistic to allow for the true difference that exists among different projects or programs, therefore we have more reason to apply random-effects model to analysis the true effect size of CBFM. Also, with the integration of control group difference in the effect sizes, meta-analysis is able to generate more accuate and powerful conclusion for seperation of true effect from the total effect by considering and controlling the natural trend. With more and more project or program evaluation/report utilize the control group for perfomance analysis, it is strongly recommeded to have control group difference integrated in the effect size as there is sizeable magnitude of misestimate of the true effect of CBFM (in the study of Cambodia).

This study was not an exhausted performance evaluation because of the limited indicators and qualified project/program availability. The precision of this meta-analysis could be improved by utilizing true sample varince if the raw dataset of ecah individual study was accessible, rahter than using the asytomptic distribution estimate of the effect size varince. Also, the meta-analysis could generate more conclusion about fisheries resource and fishers' livelihood if more common indicators from individual studies were available. Lastly, the statistic power of the estimate of effect sizes could be bigger if there is previous meta-analysis also focused on the impact of CBFM. Beacause with the addion of previous meta-analysis, the sample size would be vastly boosted and therefore the precision of this meta-analysis would be further increased.

Rather than narrative synthesis, which suffers from the subjectivity of drawing a conclusion from various studies, meta-analysis is capable of statistically synthesizing the data to discover the direction and magnitude of the summary effect of CBFM across projects and programs, in a transparent, objective, and replicable manner (Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009). Moreover, the results could be used as relevant information for institutions and donors who want to apply community-based fisheries for rural development and fisheries resource management. With the application of meta-analysis to this research in three Asian countries, a clearer and measurable realization of true effects brought by CBFM were revealed by the estimate of weighted mean effect sizes and their confidence intervals. The explicit and intuitive results from meta-analysis on projects or programs assessment make a better sense not only to the managers (e.g. government, NGOs) for knowing the true effects of interventions and deploying adaptive management but also to the actual resource user, fishers, for better relating their fishing activities under interventions to the overall resource status and their livelihood. Moreover, by the nature of meta-analysis, with more applications of meta-analysis on CBFM or any other fisheries resource management, every individual meta-analysis will be presented as a critical input (individual study in the meta-analysis) of all further ones to increase the estimate precision and statistical power.

REFERENCES

Abadie, A., 2005. Semiparametric difference-in-idifferences estimators. Rev. Econ. Stud. 72, 1-19. http://dx.doi.org/10.1111/0034-6527.00321.

ADB, 2010. Cambodia: Tonle Sap environmental management project. Asian Development Bank.

Agbayani, R.F., 1995. Community fishery resources management in malalison Island, Philippines, in: Flores, T.U.B.E.E.C. (Ed.), Towards sustainable aquaculture in Southeast Asia and Japan, Iloilo City, Philippines, 209-219.

Agnew, D., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J.R., Pitcher, T.J., 2009. Estimating the worldwide extent of illegal fishing. PLoS One, 4.

Ahmed, M., Capistrano, D., Hossain, M.M., 1992. Redirecting benefits to genuine fishers: Bangladesh's new fisheries management policy, The ICLARM Quarterly. Naga, Dhaka, Bangladesh.

Ahmed, M., Delgado, C., Sverdrup-Jensen, S., 1997. A brief for fisheries policy research in developing countries. ICLARM, Manila, Philippines.

Ahmed, M., Navy, H., Vuthy, L., Tiongco, M., 1998. Socio-economic assessment of freshwater capture fisheries of Cambodia: report on a household survey. Mekong River Commission, Phnom Penh, Cambodia.

Ali, M.Y., 1997. Fish, water and people: Reflections on inland open water fisheries resources of Bangladesh, Dhaka, Bangladesh.

Alkire, W.H., 1965. Lamnotrk Atoll and interisland socioeconomic ties. Ph.D. dissertation, University of Illinois, Ann Arbor, Michigan.

Allison, E.H., 2011. Aquaculture, fisheries, poverty and food security, Working Paper 2011-65. WorldFish Center, Penang, Malaysia.

Allison, E.H., Béné, C., Andrew, N.L., 2011. Poverty reductino as a means to enhance resilience in small-scale fisheries. In Pomeroy, R. & Andrew, N.L. (Eds.), Managing small-scale fisheries: Frameworks and approaches. CABI. London.

Allison, E.H., Ellis, F., 2001. The livelihoods approach and management of small-scale fisheries. Mar. Policy, 25. 377-388.

Amar, E., Cheong, R., Tambasen-Cheong, V., Clarissa, L., Garcia, L., Ma, B., 2009. Community fishery resource management (CBFM) (Philippines): small-scale fisheries and yield of coral reefs in malalison island, west-central Philippines.

Bailey, C., Jentoft, S., 1990. Hard choices in fisheries development. Mar. Policy, 14. 333-344. https://doi.org/10.1016/0308-597X(90)90055-V.

Baird, I.G., Flaherty, M.S., 2005. Mekong river fish conservation zones in southern Laos: assessing effectiveness using local ecological knowledge. Environ. Manage. 36, 439-454. http://dx.doi.org/10.1007/s00267-005-3093-7.

Bank, W., 2015. Bangladesh development update. The World Bank, Dhaka, Bangladesh.

Baran, E., 2010. Mekong fisheries and mainstream dams. International Centre for Environmental Management. Mekong River Commission, Phnom Penh, Cambodia.

Baran, E., Gallego, G., 2015. Cambodia's fisheries: A decade of changes and evolution. The WorldFish Center. Mekong River Commission, Phnom Penh, Cambodia.

Baran, E., Samadee, S., Shwu Jiau, T., Thanh Cong, T., 2011. Fish and fisheries in the sesan river basin: catchment baseline, fisheries section. The WorldFish Center. Phnom Penh, Cambodia.

Barbosa, C.C., Dearing, J.A., Szabo, S., Matthews, Z., 2016. Evolutionary social and biogeophysical changes in the Amazon, Ganges–Brahmaputra–Meghna and Mekong deltas. Sustainability Science 11, 1-20. http://dx.doi.org/10.1007/s11625-016-0371-7.

Barut, N.C., Santos, M.D., Mijares, L.L., Subade, R., Armada, N.B., Garces, L.R., 2003. Philippine coastal fisheries situation. In: Silvestre, G, Garces, L, Stobutzki, I, editors. Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries. Penang, Malaysia.

Baticados DB, Agbayani, R.F., 2000. Co-management in marine fisheries in Malalison Island, central Philippines. Int. J. Sust. Dev. World 17, 343-355. http://dx.doi.org/10.1080/13504500009470053.

Batista, V.S., Fabre, N.N, Malhado, A.C.M., Ladle, R.J., 2014. Tropical artisanl coastal fisheries: Challenges and future directions. Reviews in Fisheries Science and Aquaculture, 22. 1-15.

BBS, 2008. Handbook of agricultural statistics. Bangladesh Bureau of Statistics, Dhaka.

Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R., 2001. Managing small-scale fisheries: alternative directions and methods, IDRC.

Béné, C., Hersoug, B., Allison, E.H., 2010. Not by rent alone: analyzing the pro-poor functions of small-scale fisheries in developing countries. Dev. Policy Rev. 28, 325-358. http://dx.doi.org/10.1111/j.1467-7679.2010.00486.

Béné, C., Macfadyen, G., Allison, E.H., 2007. Increasing the contribution of small-scale fisheries to poverty alleviation and food security. FAO Fisheries Technical Paper No. 481. Rome, Italy.

Béné, C., Neiland, A., Jolley, T., Ladu, B., Ovie, S., Sule, O., Baba, O., Belal, E., Mindjimba, K., Tiotsop, F., Dara, L., Zakara, A., Quensiere, J., 2003. Inland fisheries, poverty, and rural livelihoods in the lake Chad basin. J. Asian Afr. Stud. 38. http://dx.doi.org/10.1007/s 10745-013-9567-y.

Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R., 2001. Managing small-scale fisheries: Alternative directions and methods. International Development Research Centre, Ottawa, ON, Canada.

Billon, P.L., 2001. The political ecology of war: natural resources and armed conflicts. Polit. Geogr. 20, 561-584. http://dx.doi.org/10.1016/S0962-6298(01)00015-4.

Boreak, S., 2000. Land ownership, sale, and concentration in Cambodia: a preliminary review of secondary data and primary data from four recent surveys. Cambodia Development Resource Institute, Phnom Penh, Cambodia.

Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009. Introduction to meta-analysis. Chichester, U.K., John Wiley and Sons.

Bush, S.R., 2008. Contextualizing fisheries policy in the lower Mekong basin. J. Southe. Asian Stud. 39, 329-353. http://dx.doi.org/10.1017/S0022463408000349.

Card, N.A., 2012. Methodology in the social sciences: applied meta-analysis for social science research. The Guildford Press, New York, U.S.

Chen, S., Ravallion, M., 2000. How did the world's poorest fare in the 1990s?. Rev. Income Wealth 47, 283-300. http://dx.doi.org/10.1111/1475-4991.00018.

Chuenpagdee, R., Preikshot, D., Liguori, L., Pauly, D, 2006. A public sentiment index for ecosystem management. Ecosystems, 9. 463-473.

Chum, N., Baran, E., Chervier, C., Leng, S.V., Emmett, D., 2010. The contribution of Kampong Preak Fish Sanctuary (Tonle Sap Lake, Cambodia) to Livelihoods in Two Adjacent Floating Villages. Int. J. Environ. Rural Dev. 1, 119-124.

Chusak, W., Vandergeest, P., 2010. The Politics of Decentralization: Natural Resource Management in Asia. Sillkworm Books.

Cobb, L., Gibson, C., Stauffer, P., 2007. Implementing Community Based Ocean Management on the Oregon Coast Proceedings of Coastal Zone 07 Portland, Oregon.

Cochran, W.G., 1954. The combination of estimates form different experiments. Biometrics 10, 101-129. http://dx.doi.org/10.2307/3001666.

Cock, A., 2010. Anticipating an oil boom: The 'resource curse' thesis in the play of Cambodian politics. Pac. Aff. 83, 525-546. https://doi.org/10.5509/2010833525.

Cohen, L.E., 1988. Statistical power analysis for the behavioral sciences (2nd ed.). Lawrence Earlbaum Associates, Hillside, NJ.

Cohen, L.E., Land, K.C., 1987. Age structure and crime: Symmetry versus asymmetry and the projection of crime rates through the 1990s. Am. Social. Rev. 52, 170-183. http://dx.doi.org/10.2307/2095446.

Cogels, O., 2004. An introduction to Cambodia's inland fisheries. Mekong River Commission, Phnom Penh, Cambodia.

Colavito, L., 2002. Wetland economic valuation using a bioeconomic model: The case of hail haor, Bangladesh, Conservation and sustainable use of wetlands: learning from the world. The world conservation union, Kathmandu, Nepal.

Collier, W.L., Hadikoesworo, H., Saropie, S., 1979. Income, employment, and food systems in Havanese costal villages. Ohio University Center for International Studies, Southeast Asia Program, Athens, Ohio.

Crawford, B., 2002. Seaweed farming: an alternative livelihood for small-scale fishers? Coastal Resource Center, University of Rhode Island.

Craig, J.F., Halls, A.S., Barr, J.J., Bean, C.W., 2004. The Bangladesh floodplain fisheries. Fish. Res. 66, 272-286. http://dx.doi.org/10.1016/S0165-7836(03)00196-6 272.

CRMP, 2004. Completion Report: The Coastal Resource Management Project-Philippines 1996-2004. Coastal resource management project of the department of environment and natural resources. Cebu City, Philippines.

Csavas, I., Debas, L., Doulman, D.J., Petr, T.O., Prado, J., 1994. Cambodia - rehabilitation and development needs of the fishery sector. The Food and Agriculture Organization of the United Nations, Rome.

Deepananda, K.H.M.A., Amarasinghe, U.S., Jayasinghe-Mudalige, U.K., 2015. Indigenous knowledge in the beach seine fisheries in Sri Lanka: an indispensable factor in community-based fisheries management. Mar. Policy 57, 69-77. http://dx.doi.org/10.1016/j.marpol.2015.03.028.

Degen, P., Van Acker, F., van Zalinge, N., Thuok, N., Vuthy, L., 2000. Taken for granted: conflicts over Cambodia's freshwater fish resources, International Association for the Study of the Common Property (IASCP), Bloomington, Indiana.

Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S., Ahmed, M., 2003. Fish to 2020: Supply and demand in changing global markets. International Food Policy Research Institute, Washington, D.C., WorldFish Center, Penang, Malaysia.

DerSimonian, R., Laird, N., 1986. Meta-analysis in clinical trials. Control. Clin. Trials 7, 177-188. http://dx.doi.org/10.1016/0197-2456(86)90046-2.

Dey, M.M., Kanagaratnam, U., 2007. Community-based management of small-scale fisheries in Asia: Bridging the gap between fish supply and demand. The WorldFish Center, Dhaka, Bangladesh.

DFID, 1999. Sustainable livelihoods and poverty elimination. Department for International Development, London.

DIFD, 2000. Sustainable livelihoods - current thinking and practice. Department for International Development, London.

DoF, 2006. National fisheries strategy and action plan for the implementation of the national fisheries strategy, Department of Fisheries, Dhaka, Bangladesh.

Dohrn, C.L., 2013. A new commons: Considering Community-based co-management for sustainable fisheries. Pomona College, Claremont.

Dorward, A., Kydd, J., 2003. Policy reform in sub Saharan Africa. IDEAS Working Paper Series from RePEc.

Duc S'an, T., Todd, B.H., 2003. The inland and marine fisheries trade of Cambodia. Oxfam America, Cambodia.

El-Noush, H., 2010. Cambodia food market analysis and survey report. World Food Programme Cambodia.

Evans, P., 2002. Fishing disarmed Samudra Report. International Collective in Support of Fishworkers.

Eysenck, H.J., 1952. The Effects of Psychotherapy: An Evaluation. Journal of Consulting Psychology, 16, 319-324.

Fan, S., 2010. Halving hunger: meeting the first Millennium Development Goal through business as unusual. International Food Policy Research Institute, Washington D.C.

FAO, 2005. Increasing the contribution of small-scale fisheries to poverty alleviation and food security. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO, 2010. The status of world fisheries and aquaculture. FAO. Rome, Italy.

FAO, 2011. Fao Fishery country profile - the Kingdom of Cambodia, FID/CP/KHM. The Food and Agriculture Organization of the United Nations.

FAO, 2014. Fishery and aquaculture country profile. The Philippines, FAO Fisheries and Aquaculture Department, Rome.

FAO, SPC, 2010. Report of the FAO/SPC Regional Workshop on Improving Information on Status and Trends of Fisheries in the Pacific Region, Apia, Samoa, 2010 FAO Fisheries and Aquaculture Report.

Feeroz, M.M., 2013. Introduction: Protected areas, in Feeroz, M.M. (Ed.), Biodiversity of protected areas of Bangladesh, volume iii, teknaf wildlife sanctuary. Arannayk Foundation, Bangladesh.

Fehr, E., Fishbacher, U., 2003. The nature of human altruism. Nature 425, 785-791. http:dx.doi.org/10.1038/nature02043.

Ferrer, E.M., Cruz, L.P., Domingo, M.A., 1996. Seeds of Hope: A collection of case studies on community-based costal resources management in the Philippines. University of the Philippines, Diliman, Quezon City, Philippines.

Ferrer, E.M., Nozawa, C.M.C., 1997. Community-based coastal resources management in the Philippines: Key concepts, methods, and lessons learned, University of Philippines, Quezon City, Philippines.

FiA, 2009. Fishing for the future: the strategic planning framework for fisheries (2010-2019). Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia.

FiA, 2012. The strategic planning framework for fisheries: 2010-2019. Fisheries Administration, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia.

FISH, 2010. Completion report: The Fisheries Improved for Sustainable Harvest (FISH) Project 2003-2010. Department of Agricultural-Bureau of Fisheries and Aquatic Resources, Cebu City, Philippines.

Foster-Turley, P., Das, R., Hansan, M.K., Hossain, P.R., 2016. Bangladesh tropical forests and biodiversity assessment. USAID, Dhaka, Bangladesh.

Foresingt, 2011. The future of food and farming. Final Project Report. The Government Office for Science, London.

Froese, R., Zeller, D., Kleisner, K., Pauly, D., 2013. Worrisome trends in global stock status continue unabated: a response to a comment by R.M. Cook on "What catch data can tell us about the status of global fisheries". Mar. Biol. 160. 2531-2533. http://dx.doi.org/10.1007/s00227-013-2185-9.

Garcia, S.M., C. Newton. 1995. Current Situation, Trends and Prospects in World Capture Fisheries. Presented at the Conference on Fisheries Management, Global Trends, FAO Fisheries Department, Rome Italy.

Gerrodette, T., Dayton, P.K., Macinko, S., Fogarty, M., 2002. Precautionary management of marine fisheries: Moving beyond burden of proof. Bulletin of Marine Science, 70. 657-668.

Glass, G.V., McGaw, B., Smith, M.L., 1981. Meta-analysis in social research. SAGE Publications, Beverly Hills, CA.

Gough, I., McGregor, J.A., Camfield, L., 2007. Theorising wellbeing in international development. Cambridge University Press.

GPRB, 2005. The constitution of the people's republic of Bangladesh. The government of Bangladesh.

Graham, J., Charles, A., Bull, A., 2006. Community fisheries management hand book. Saint Mary's University, Gorsebrook Research Institute.

Graham, P.L & Moran J.L., 2012. Robust meta-analytic conclusions mandate the provision of prediction intervals in meta-analysis summaries. J. Clin. Epidemiol. 65, 503-510. http://dx.doi.org/10.1016/j/jclinepi.2011.09.012.

Gray, D., Mueller, V., 2012. Natural disasters and population mobility in Bangladesh. Proceedings of the National Academy of Sciences 109. 6000-6005. http:dx.doi.org/10.1073/pnas.1115944109.

Green, S.J., White, A.T., Flores, J.O., Careon, M.F., Sia, A.E, 2003. Philippine fisheries in crisis: A framework for management. Coastal Resource Management Project of the Department of Environment and Natural Resources, Cebu City, Philippines.

Grissom, R.J., Kim, J.J., 2005. Effect sizes for research: A broad practical approach Lawrence Erlbaum, Mahwah, NJ.

Gupta, M.V., Sollows, J.D., Mazid, M.A., Rahman, A., Hussain, M.G., Dey, M.M., 1998. Integrating aquaculture with rice farming in Bangladesh: Feasibility and economic viability, its adoption and impact. ICLARM, Dhaka, Bangladesh.

Haan, L., Zoomers, A., 2003. Development geography at the crossroads of livelihood and globalisation. J. Econ. Social Geo. 94. 350-362.

Hanna, S., 1995. User participation and fishery management performance within the Pacific fishery management council. Ocean Coast. Manage. 28, 23-44. http://dx.doi.org/ 10.1016/0964-5691(95)00046-1.

Haughton, J., Khandker, S.R., 2009. Handbook on poverty and inequality. World Bank, Washington, D.C.

Hawkins, J.P., Roberts, C.M., 2004. Effects of artisanal fishing on Caribbean coral reefs. Conserv. Biol. 18, 215-226.

Hedges, L.V., 1981. Distribution theory for glass's estimator of effect size and related estimators. J. Educ. Stat. 6, 107-128. http://dx.doi.org/ 10.3102/10769986006002107.

Hedges, L.V., Gurevitch, J., Curtis, P.S., 1999. The meta-analysis of response ratios in experimental ecology. Ecology 80, 1150-1156. http://dx.doi.org/10.2307/177062.

Hedges, L.V., Olkin, I., 1985. Statistical methods for meta-analysis. Academic Press, Orlando.

Herrin, A.N., Fabello, C.E., Palma, L.C., 1978. A social and economic study of selected municipal fishing communities in Misamis Oriental, Philippines. Research Institute of Mindanao Culture, Xavier University, Cahayan de Oro City, Philippines.

Higgins, J.P.T., Thompson, S.G., 2002. Quantifying heterogeneities in the meta-analysis. Stat. Med. 21, 1539-1558. http://dx.doi.org/10.1002/sim.1186.

Higgins, J.P.T., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003. Measuring inconsistency in meta-analyses. Brit. Med. J. 327, 557-560. http://dx.doi.org/10.1136/bmj.327.7414.557.

Higgins, J.P.T., Thompson, S.G., Spiegelhalter, D.J., 2009. A re-evaluation of random-effects in the meta-analysis. J. Roy. Stat. Soc. A. Sta. 172, 137-159. http://dx.doi.org/10.1111/j.1467-985X.2008.00552.X.

Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K., Knowlton, N, Eakin, C.M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R.H., Dubi, A., Hatziolos, M.E., 2007.

Coral reefs under rapid climate change and ocean acidification. Science, 318. 1737-1742. http://dx.doi.org/10.1126/science.1152509.

Hoggarth, D.D., Kirkwood, G.P., 1996. Technical interactions in tropical floodplain fisheries of south and southeast Asia, in: Cowx, I.G. (Ed.), Stock assessment in inland fisheries. Fishing News Books, Oxford.

Hossain, M., Islam, K., Andrew, J., 2006. Corporate social and environmental disclosure in developing countries: Evidence from Bangladesh, Faculty of Commerce papers. University of Wollongong, New South Wales, Australia.

Huda, A.T.M.S., 2003. Fishing in muddy waters: Policy process for inland fisheries in bangladesh., Community Based Fisheries Management Project Working Paper 3. WorldFish Center, Dhaka, Bangladesh.

Huedo-Medina, T.B., Sánchez-Meca, J., Marín-Martínez, F., Botella, J., 2006. Assessing heterogeneity in meta-analysis: Q statistic or i2 index? Psychol. Methods 11, 193-206. http://dx.doi.org/10.1037/1082-989x.11.2.193.

ICF, 2006. The importance of wild fisheries for food security and nutrition, Fishing for Food Security. ICF International, Dhaka, Bangladesh.

IFAD, ANGOC, IIRR, 2001. Enhancing ownership and sustainability: a resource book on participation. IFAD, ANGOC, IIRR.

IFReDI, 2013. Food and nutrition security vulnerability to mainstream hydropower dam development in Cambodia. Inland Fisheries Research and Development Institute, Fisheries Administration, Phnom Penh, Cambodia.

Islam, F.U., 2007. Self-recruiting species (SRS) in aquaculture: their role in rural livelihoods in two areas of Bangladesh. The University of Stirling.

Islam, G., Dickson, M.W., 2006. Livelihood impacts of community-based fisheries management project, phase 2 (CBFM-2). WorldFish Center, Bangladesh and South Asia Office, Dhaka. Bangladesh.

Islam, G., Yew, T.S., 2013. Property rights and access: The case of community-based fisheries management in Bangladesh. J. Agr. Sci. 5, 164-170. http://dx.doi.org/10.5539/jas.v5n6p164.

Islam, G., Yew, T.S., Abdullah, N.M.R., Viswanathan, K.K., 2011. Social capital, community-based management and fishers' livelihood in Bangladesh. Ocean Coast. Manage. 54, 173-180. http://dx.doi.org/10.1016/j.ocecoaman.2010.10.026.

Islam, G., Yew, T.S., Viswanathan, K.K., 2014. Poverty and livelihood impacts of community-based fisheries management in Bangladesh. Ocean Coast. Manage. 96, 123-129. http://dx.doi.org/10.1016/j.ocecoaman.2014.05.004

Islam, M.A., Majlis, A.B.K., Rashid, M.B., 2011. Changing the face of Bangladesh. J. NOAMI 28.

Israel, D.C., 2001. Review of methods for assessing community-based coastal resources management in the Philippines. Discussion paper series No. 2001-26. Phillippines institute for development studies. Makati, Philippines.

Jacquet, J.L., Pauly, D., 2008. Trade secrets: renaming and mislabeling of seafood. Marine Policy 32:309-318.

Jentoft, S., 2005. Fisheries co-management as empowerment. Mar. Policy 29, 1-7. http://dx.doi.org/10.1016/j.marpol.2004.01.003.

Jentoft, S., McCay, B.J., 2003. The place of civil society in fisheries management: A key focus of social research, in Wilson, D.C., Degnbol, P., Nielsen, J.R. (Eds.), The fisheries co-management experience: Accomplishments, Challenges and prospects. Kluwer.

Juinio-Menez, M.A., Salmo, S., Tamayo, E., Estepa, N., Bangi, H., Alino, P., 2000. Community environmental education: Experiences from Bolinas, northern Philippines, Community-based coastal resources management program. Marine Science Institute, University of the Philippines, Quezon City, Philippines.

Kabir, K., Saha, N.C., Oliveras, E., Gazi, R., 2013. Association of programmatic factors with low contraceptive prevalence rates in a rural area of Bangladesh. Reproductive Health 2013, 10-31. http://dx.doi.org/10.1186/1742-4755-10-3.

Kabir, G.M., Yew, T.S., Noh, K., Law, S.H., 2011. Assessing fishers' empowerment in inland open water fisheries in Bangladesh. Ecol. Econ. 70, 2114-2123. http://dx.doi.org/10.1016/j.ecolecon.2011.06.009.

Karim, H., 1988. Shamanism in Bangladesh. Asian Folklore Studies 47, 277-309. http://dx.doi.org/10.2307/1178280.

Karim, M., 2006. The livelihood impacts of fishponds integrated within farming systems in Mymensingh district, Bangladesh. The university of Stirling.

Katon, B., Pomeroy, R.S., 1999. Fisheries management of San Salvador Island, Philippines: A shared responsibility. Society and Natural Resources 12, 775-795. http://dx.doi.org/ 10.1080/089419299279317.

Kawarazuka, N., 2010. The contribution of fish intake, aquaculture, and small-scale fisheries to improving nutrition: A literature review. WorldFish Center.

Kawarazuka, N., Béné, C., 2011. The potential role of small fish species in improving micronutrient deficiencies in developing countries: Building evidence. Public Health Nutrition 14, 1927-1938. http://dx.doi.org/10.1017/S1368980011000814.

Keskinen, Marko, Kummu, M., Salmivaara, A., Someth, P., Lauri, H., Moel, H.d., Ward, P., Pech, S., 2013. Tonle sap now and in the future? Water & Development Research Group, Aalto University.

Khan, F., Mustafa, M.G., Naser, N.M., 2016. Effective supervision of inland capture fisheries of Bangladesh and its hurdles in managing the resources. J. Global South 3, 17-30. http://dx.doi.org/10.1186/s40728-015-0026-6.

Kishigami, N., Savelle, J.M., Kokuritsu Minzokugaku, H., 2004. Indigenous use and management of marine resources. National Museum of Ethnology, Suita, Osaka.

Knowles, J.C., 2009. Poverty profile and trend in Cambodia : findings from the 2007 Cambodia socio-economic survey (CSES). World Bank, Washington, D.C.

Kroeker, K.J., Kordas, R.L., Crim, R.N., Singh, G.G., 2010. Meta-analysis reveals negative yet variable effects of ocean acidification on marine organisms. Ecol. Lett. 13, 1419-1434. http://dx.doi.org/ 10.1111/j.1461-0248.2010.01518.x.

Kura, Y., Revenga, C., Hoshino, E., Mock, G., 2004. Fishing for Answers: Making Sense of the Global Fish Crisis. Washington (DC): World Resources Institute.

Kurien, J., So, N., Mao, S.O., 2006. Cambodia's aquarian reforms: the emerging challenges for policy and research. Inland Fisheries Research and Development Institute, Phnom Penh, Cambodia.

Lajeunesse, M.J., 2011. On the meta-analysis of response ratio for studies with correlated and multi-group designs. Ecology 92, 2049-2055. http://dx.doi.org/10.1890/11-0423.1.

Lalli, C.M., Parsons, T.R., 1993. Biological oceanography: An introduction. Pergamon Press Ltd., Oxford.

Le Billon, P., 2000. The political ecology of transition in Cambodia 1989-1999: war, peace and forest exploitation. Dev. Change 31, 785-805. http://dx.doi.org/10.1111/1467-7660.00177.

Lechner, M., 2011. The estimation of casual effects by difference-in-difference methods. Found. The trend in Economic. 4, 165-224. http://dx.doi.org/10.1561/0800000014.

Lechner, M., 2010. The estimation of causal effect by difference-in-difference methods. Econometrics 4, 165-224. http://dx.doi.org/10.1561/0800000014.

Lenselink, N.M., 2002. Participation in artisanal fisheries management for improved livelihoods in West Africa. A synthesis of interviews and cases from Mauritania, Senegal, guinea and Ghana, FAO Fisheries Technical Paper. No. 432. FAO, Rome, Italy.

Lieng, S., Van Zalinge, N., 2001. Fish yield estimation in the floodplains of the Tonle Sap great lake and river. Inland Fisheries Research and Development Institute of Cambodia (IFReDI), Cambodia.

Lipsey, M.W., Wilson, D.B., 2001. Practical meta-analysis. SAGE Publications, Thousand Oaks, California, U.S.

Lise, W., 2000. Factors influencing people's participation in forest management in India. Ecol. Econ. 34, 379-392. http://dx.doi.org/10.1016/j.forpol.2011.02.005.

Lobe, K., Berkes, D., 2004. The padu system of community-based resource management: change and local institutional innovation in South India. Mar. Policy 28, 271-281. http://dx.doi.org/ 10.1016/S0308-597x(03)00087-3.

Lorenzen, k.,Choulamany, X., Sultana, P., 2003. Understanding livelihoods dependent on inland fisheries in Bangladesh and Southeast Asia. Lao PDR country status report. WorldFish Center, Penang, Malaysia.

Macauslan, I., Phelps, L., 2012. Oxfam GB emergency food security and livelihoods urban program evaluation. Oxform Policy Management Limited, England.

MacKenney, B., Tola, P., 2002. Natural resources and rural livelihoods in Cambodia: a baseline assessment, Phnom Penh, Cambodia.

Maliao, R.J., 2002. Protecting the commons and sustainable development: Evaluating the impacts of marine protected area in sagay, Negros occidental, western Philippines. Asian Institue of Technology, Pathumthani, Thailand.

Marschke, M., 2003. From planning to action: What can resources management committees do "on the ground"? Cambodia Dev. Rev. 7, 7-12.

Marschke, M., 2012. Life, fish, and mangroves: resource governance in coastal Cambodia. University of Ottawa Press, Ottawa, Canada.

Marschke, M., Nong, K., 2003. Adaptive co-management: Lessons from coastal Cambodia. J. Can. Dev. Stud. 24, 369-384. http://dx.doi.org/10.1080/02255189.2003.9668927.

Marschke, M., Sinclair, J., 2009. Learning for sustainability through participatory resource management. J. Environ. Manage. 90, 206-216. http://dx.doi.org/10.1080/02255189.2003.9668927.

Matschullat, J., Freiberg, B., 2014. Atlas of Cambodia: maps on socio-economic development and environment, Phnom Penh, Cambodia.

McCay, B.J., 1996. Participation of fishers in fisheries management, in: Meyer, R.M., Jhang, C., Windsor, M.L., McCay, B.J., Hushak, L.J., Muth, R.M. (Eds.), Fisheries resource utilization and policy. Oxford & IBH Publishing CO. Pvt. Ltd., New Delhi, India.

McClanahan, T.R., Castilla Z, J.C., Wiley, I., 2007. Fisheries management: progress towards sustainability.

McGoodwin, J.R., 2001. Understanding the cultures of fishing communities: A key to fisheries management and food security. Food and Agriculture Organization of the United Nations, Rome.

Mills, D.J., Westlund, L., De Greef, G., Kelleher, K., 2011. Under-reported and Undervalued: small-scale fisheries in the developing world, in: Pomeroy, R.S., & Andrew, L. (Eds.) Small-scale fisheries management: Frameworks and approaches for the developing world, . CABI.

Mohan Dey, M., Rab, M.A., Paraguas, F.J., Piumsombun, S., Bhatta, R., Ferdous Alam, M., Ahmed, M., 2005. Fish consumption and food security: A disaggregated analysis by types of fish and classes of consumers in selected Asian countries. Aquatic. Econ. Manage. 9, 89-111. http://dx.doi.org/ 10.1080/13657300590961537.

Moore, J.C., Stinson, L.L., Welniak, E.J., 2002. Income measurement error in surveys: a review. J. Off. Stat. 16, 331-361.

Morgan, D.G., Abdallah, S.B., Lasserre, P., 2007. Real options approach to forest management decision making to protect caribou under the threat of extinction. Ecology and Society, 13.

Muallil, R.N., Cleland, D., Alino, P.M., 2013. Socioeconomic factors associated with fishing pressure in small-scale fisheries along the west Philippine sea biogeographic region. Ocean Coast. Manage 82, 27-33. http://dx.doi.org/10.1016/j.ocecoaman.2013.04.013.

Muallil, R.N., Mamauag, S.S., Cababaro, J.T., Arceo, H.O., Alino, P.M., 2014. Catch trends in Philippine small-scale fisheries over the last five decades: The fishers′ perspectives. Mar. Policy 47, 110-117. http://dx.doi.org/10.1016/j.marpol.2014.02.008.

Muir, J.F., 2003. The future for fisheries: Economic performance, Fisheries Sector Review, and Future Development Study. World Bank, DANIDA, USAID, FAO, DFID, Dhaka, Bangladesh.

Mustafa, M.G., Halls, A.S., 2007. The impact of the community-based fisheries management on the sustainable use of inland fisheries in Bangladesh. WorldFish Center, Dhaka, Bangladesh.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853-858. http://dx.doi.org/10.1038/35002501.

National Institution of Statistics, 2007. Food insecurity assessment in Cambodia. National Institute of Statistics and Food and Agriculture Organization of the United Nations, Phnom Penh, Cambodia.

National Institution of Statistics, 2009. Food insecurity assessment in Cambodia. National Institution of Statistics, Phnom Penh, Cambodia.

Navy, H., Bhattarai, M., 2006. Economic assessment of small-scale inland fisheries and wetland livelihoods in Cambodia, International Riversymposium, Brisbane, Australia.

NEDECO, 1998. The natural resources-based development strategy for the Tonle Sap area, Cambodia: final report. Cambodia National Mekong Committee, Phnom Penh, Cambodia.

NGO Forum on Cambodia, 2009. Statistic analysis on land dispute occurring in Cambodia 2008, Phnom Penh, Cambodia.

Nickerson-Tietze, D.J., 2010. Community-based management of sustainable fisheries resources in phang-Nga Bay, Thailand. Coast. Manage. 28, 65-74. http://dx.doi.org/10.1080/089207500263657.

Nielsen, J., Vedsmand, T., 1999. User participation and institutional change in fisheries management: a viable alternative to the failures of 'top-down' driven control? Ocean Coast. Manage. 42, 19-37. http://dx.doi.org/1016/S0964-5691(98)00085-4.

Nissapa, A., Khemakorn, P., Masae, A., Siripech, A., 2005. Aspects of fisheries conflicts and suggested mitigating measures between anchovy and small scale fisheries in Songkla Province, Thailand. Penang, Malaysia.

Nith, C., 2009. Contribution of natural resources to livelihoods in two floating villages near Kampong Prak fish sanctuary. Royal University of Agriculture, Cambodia.

Oxfam, 2003. Evaluation of the impact of the fisheries reform in Cambodia on the livelihood of poor fishers. Oxfam, Phnom Penh, Cambodia.

Paillard, S., Treyer, S., Dorin, B., 2011. Agrimonde: Scenarios and Chanllenges for Feeding the World in 2050. Paris, French.

Pauly, D., 2006. Major trends in small-scale marine fisheries, with emphasis on developing countries, and some implications for the social sciences. Maritime Studies (MAST) 4:7-22.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., Torres, F., 1998. Fishing down marine food webs. Science 279, 860-863. http://dx.doi.org/10.1126/science.279.5352.860.

Pauly, D., Christensen, V., Sambilay, V.C., 1990. Some features of fish food consumption estimates used by ecosystem modelers. ICES Council Meeting, London.

Pel, S., Yonekura, Y., So, S., Saito, K., 2005. Land issue study in Cambodia: Landlessness, land disputes and project affected people. Centre d'Etude et de Development Agricole Cambodgien and Japan International Volunteer Center, Phnom Penh, Cambodia.

Pemsl, D.E., Seidel-Lass, L., 2010. Informal networks in policy processes: The case of community-based fisheries management in Bangladesh. J. Dev. Eff. 2, 486-503. http://dx.doi.org/10.1080/19439342.2010.525246.

PMCR, 2008. Learning for change: ten years of experience in community-based coastal resource management and livelihood improvement in Koh Kong, Cambodia. CBNRM Learning Institue, Phnom Penh, Cambodia.

Pomeroy, R.S., 1994. Community management and common property of coastal fisheries in Asia and the Pacific: Concepts, methods, and experiences. International Center for Living Aquatic Resources Management, Makati, Metro Manila, Philippines.

Pomeroy, R.S., 1995. Community-based and co-management institutions for sustainable coastal fisheries management in Southeast Asia. Ocean Coast. Manage. 27, 142-162. http://dx.doi.org/10.1016/0964-5691(95)00042-9.

Pomeroy, R.S., Andrew, N., 2011. Small-scale fisheries management: frameworks and approaches for the developing world. CAB International, Wallingford, Oxfordshire, UK; Cambridge, MA.

Pomeroy, R.S., Berkes, F., 1997. Two to tango: the role of government in fisheries co-management. Mar. Policy 21, 465-480. http://dx.doi.org/10.1016/s0308-597x(97)00017-1.

Pomeroy, R.S., Carlos, M.B., 1997. Community-based coastal resource management in the Philippines: A review and evaluation of programs and projects, 1984-1994. Mar. Policy 21, 445-464. http://dx.doi.org/ 10.1016/j.marpol.2009.03.003.

Pomeroy, R.S., Katon, B.M., Harkes, I., 2001. Conditions affecting the success of fisheries co-management: Lessons from Asia. Mar. Policy 25, 197-208. http://dx.doi.org/10.1016/S0308-597X(01)00010-0.

Pomeroy, R.S., Parks, J., Mrakovcich, K.L., LaMonica, C., 2016. Drivers and impacts of fisheries scarcity, competition, and conflict on maritime security. Mar. Policy 67, 94-104. http://dx.doi.org/ 10.1016/j.marpol.2016.01.005.

Pomeroy, R.S., Parks, J., Pollnac, R., Campson, T., Genio, E., Marlessy, C., Holle, E., Pido, M., Nissapa, A., Boromthanarat, S., Thu Hue, N., 2007. Fish Wars: Conflict and collaboration in fisheries management in Southeast Asia. Mar. Policy 31, 645-656. http://dx.doi.org/10.1016/j.marpol.2007.03.012.

Pomeroy, R.S., Pollnac, R.B., Predo, C., Katon, B., 1996. Impact evaluation of community-based coastal resource management projects in the Philippines. NAGA 19, 4-13.

Pomeroy, R.S., Rivera-Guieb, R., 2005. Fishery co-management: A practical handbook. CABI Publishing, Cambridge.

Pomeroy, R.S., Viswanathan, K.K., 2003. Experiences with fisheries co-management in Southeast Asia and Bangladesh, in Wilson, D.C., Nielsen, J.R., Degnbol, P. (Ed.), The fisheries co-management experience: Accomplishments, challenges, and prospects. Dordrecht, Springer Netherlands.

Pomeroy, R.S., Williams, M.J., 1994. Fisheries co-management and small-scale fisheires: A policy brief. Co-management fisheries project, ICAEM, Makati City, Philippines.

Pretty, J.N., Guijt, I., Thompson, J., Scoones, I., 1995. Participatory learning and action. IIED, London.

Pritchard, M., Kenward, S., Hannan, M., 2015. The chars livelihoods program in Bangladesh: Factors that enable, constrain and sustain graduation. IDS Bulletin 46, 35-47. http://dx.doi.org/10.1111/1759-5436.12127.

Rab, M.A., Navy, H., Ahmed, M., Seng, K., Viner, K., 2006. Socioeconomics and values of resources in the great lake - Tonle Sap and Mekong - bassac area, Penang, Malaysia.

Raby, G.D., Colotelo, A.C., Blouin-Demers, G., Cooke, S.J., 2011. Freshwater commercial bycatch: an understated conservation problem. BioScience, 61, 271–280.

Rainboth, W.J., 1996. Fishes of the Cambodian Mekong. Food and Agriculture Organization of the United Nations, Rome.

Rivera-Guieb, Rebecca, Graham, J., Marschke, M., Newkirk, G.G., 2004. Different gardens, different blossoms: an analysis of the experience with community-based coastal resource management in the Philippines, Viet Nam and Cambodia, IASCP Oaxaca, Mexico.

Royal Government of Cambodia, 2003. A major achievement of the royal government of Cambodia, 1999-2002, Phnom Penh, Cambodia.

Ruddle, K., Hviding, E., Johannes, R.E., 1992. Marine resource management in the context of customary tenure. Mar. Resour. Econom., 7. 249–273.

Salayo, N., Garces, L., Pido, M., Viswanathan, K., Pomeroy, R., Ahmed, M., Siason, I., Seng, K., Masae, A., 2008. Managing excess capacity in small-scale fisheries: perspectives from stakeholders in three Southeast Asian countries. Mar. Policy 32, 692-700. http://dx.doi.org/10.1016/j.marpol.2007.12.001.

Sarker, A.C., Sultana, P., Thompson, P., 1999. Case study of community-based management of goakhola htiara beel, in: Hossain, M.M. (Ed.), Community-based fisheries management and future strategies for inland fisheries in Bangladesh. Ford Foundation, Dhaka, Bangladesh.

Sekiguchi, M., Hatusukano, N., 2013. Land conflicts and land registration in Cambodia. In J. Unruh, R.C. Williams (Eds.), Land and post-conflict peacebuilding, Earthscan, London.

Seng, K., Song, S.L., Navy, H., Leang, S., 2005. Conflicts arising from re-allocation of fishing lots: Perceptions from community fisheries in Cambodia. Inland Fisheries Research and Development Institute (IFReDI), Phnom Penh, Cambodia.

Smith, M.L., Glass, G.V., 1977. Meta-analysis of psychotherapy outcome studies. Am. Psychol. 32, 752-760. http://dx.doi.org/10.1037/0003-066x.32.9.752.

Sneddon, C., Fox, C., 2007. Power, development, and institutional change: participatory governance in the lower Mekong basin. World Dev. 35, 2161-2181. http://dx.doi.org/ 10.1016/j.worlddev.2007.02.002.

So, N., Haing, L., 2007. A review of freshwater fish seed resource in Cambodia. In M.B. Bondad-Reantaso, (Ed.), Assessment of freshwater fish seed resource for sustainable aquaculture. FAO Fisheries Technical Report Series Rome, Italy.

Sovannara, H., 2014. Overview of the fisheries sector in Cambodia, on-going collaborative activities, and achievement between FIA and CI. Phnom Penh, Cambodia.

Salayo, N., Garces, L., Pido, M., Viswanathan, K., Pomeroy, R., Ahmed, M., Siason, I., Seng, K., Masae, A., 2008. Managing excess capacity in small-scale fisheries: Perspectives from stakeholders in three Southeast Asian countries. Mar. Policy, 32. 692-700.

Scoones, I., 1999. New Ecology and the Social Sciences: What Prospects for a Fruitful Engagement? Annual Review of Anthropology, 28. 479-507.

Siason, I.M., Ferrer, A.J., Monteclaro, H.M., 2005. Philippine case study on conflicts over use of municipal water: synthesis of three study sites. Penang, Malaysia: WorldFish Center; 2005.

Sugiyama, S., Staples, D., Funge-Smith, S., 2004. Status and potential of fisheries and aquaculture in Asia and the Pacific. Bangkok, Thailand.

Stobutzki, I.C, Miller, M., Brewer, D., 2001. Sustainability of fishery bycatch: a process for assessing highly diverse and numerous bycatch. Environmental Conservation, 28: 167-181.

Stobutzki, I.C., Silvestre, G.T., Talib, A.A., Krongprom, A., Supongpan, M., Khemakorn, P., 2006. Decline of demersal coastal fisheries resources in three developing Asian countries. Fish Res. 78, 130-142. http://dx.doi.org/10.1016/j.fishres.2006.02.004.

Sultana, P., Thompson, P.M., 2007. Community-based fisheries management and fisher livelihoods: Bangladesh case studies. Hum. Ecol. 35, 527-546. http://dx.doi.org/ 10.1007/s10745-006-9092-3.

SUMACORE, 2010. Sustainable management of coastal resources projects the Kingdom of Spain.

Tanyang, G., 2001. Women in fisheries: A review of the limited literature. A paper commissioned by the NGOs for Fisheries Reform for the workshop on Fisheries and Gender.

Tawake, A., Parks, J., Radikedike, P., Aalbersberg, W., Vuki, V., Salafsky, N., 2001. Harvesting clams and data: Involving local communities in monitoring: A case in Fiji. Conserv. Biol. 2, 32-35. http://dx.doi.org/10.1111/j.1526-4629.2001.tb00020.x.

The WorldFish Center, 2011. Gender and equity: reducing poverty and hunger by improving fisheries and aquaculture. The WorldFish Center.

Thompson, P.M., 1999. Theoretical basis for community-based fisheries management in Bangladesh, Sustainable inland fisheries management in Bangladesh. International Center for Living Aquatic Resources Management, Makati City, Philippines.

Thompson, P.M., Hossain, M.M., 1998. In social and distributional issues in open water fisheries management in Bangladesh, Inland Fishery Enhancements. FAO Fish Tech. Pap., pp. 351-370.

Thompson, P.M., Sultana, P., Islam, N., 2003. Lessons from the community-based management of floodplain fisheries in Bangladesh. J. Environ. Manage. 69, 307-321. http://dx.doi.org/ 10.1016/j.jenvman.2003.09.014.

Thong, H.X., Noi, H., 2010. Co-management: The most effectiveness and effective management solution for fisheries of small reservoirs, International Institute of Fisheries Economics and Trade (IIFET) 2010, Montpellier, France.

Tietze, U., Siar, S.V., Marmulla, G., Anrooy, R.v., 2007. Credit and microfinance needs in inland capture fisheries development and conservation in Asia. Food and Agriculture Organization of the United Nations, Rome.

Try, T., 2003. Making space and access in fisheries resource management for local communities in stung treng province, Cambodia, Politics of the Commons: Articulating Development and Strengthening Local Practices Conference, Chiang Mai, Thailand.

Tupper, M., Asif, F., Garces, L.R., Pido, M.D., 2015. Evaluating the management effectiveness of marine protected areas at seven selected sites in the Philippines. Mar. Policy 56, 33-42. http://dx.doi.org/ 10.1016/j.marpol.2015.02.008.

Tyner, J.A., Lancaster, G., 2008. The Killing of Cambodia: geography, genocide and the unmaking of space. Polit. Stud. Rev. 9, 440-441. http://dx.doi.org/ 10.1604/9780754670964.

USAID, 2010. The fisheries improved for the sustainable harvest (fish) project. United States Agency for International Development.

UN, 2010. World population prospects. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, United Nations.

Un, K., So, S., 2009. Politics of natural resource use in Cambodia. Asian Aff. 79, 123-136. http://dx.doi.org/10.1080/00927670903259921.

Van Acker, F., 2010. Free riders and social fences common property, collective action and decentralized natural resource management in Cambodia. The Learning Institute, Phnom Penh, Cambodia.

Vann, L.S., 2005. Community-based fisheries management: a case study of community fisheries in former fishing lot No. 13 in Kampong Chhnang province, Cambodia. Asian Institute of Technology, Cambodia.

Van Mulekom, L.V. & Tria, E.C., 1997. Community-based coastal resource management in Orion (Bataan, Philippines): building community property rights in a fishing community. Naga 20, 51-55. ICLARM.

Viner, K., Ahmed, M., Bjlrndal, T., Lorenzen, K., 2006. Development of fisheries co-management in Cambodia : a case study and its implications. WorldFish Center, Penang, Malaysia.

Viswanathan, K.K., Nielsen, J.R., Degnbol, P., Ahmed, M., Hara, M., Nik Mustapha, R.A., 2003. Fisheries co-management policy brief: Findings from a worldwide study. WorldFish Center, Penang, Malaysia.

Virdin, J., Gardiner, P., Santen, G., 2004. Saving fish and fisheries : towards sustainable and equitable governance of the global fishing sector. The World Bank, Washington D.C.

Vuthy, T., Socheat, K., Pirom, K., Chhun, C., Dary, P., 2013. Helping address rural vulnerabilities and ecosystem stability (harvest) in Cambodia. USAID/CDRI Impact Evaluation Team.

Weber Michael L., Iudicello Suzanne, 2005. Obstacles and opportunities for community-based fisheries management in the United States, Portland, ME.

Webb, E.L., Maliao, R.J., Siar, S.V., 2004. Using local user perceptions to evaluate outcomes of protected area management: A case study of sagay marine reserve. Environ. Conserv. 31, 138-148. http://dx.doi.org/10.4103/0972-4923.92149.

White, A.T., Vogt, H.P., 2000. Philippine coral reefs under threat: Lessons learned after 25 years of community-based reef conservation. Mar. Pollut. 40, 537-550. http://dx.doi.org/10.1016/S0025-326X(99)00243-X.

Williams, S., 1999. Where has all the land gone? A review of published and unpublished materials relating to land rights and access in Cambodia, Phnom Penh, Cambodia.

World Bank, 2013. Fish to 2030: Prospects for Fisheries and Aquaculture. World Bank, Washington, D.C.

Worm, B, Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., 2006. Impacts of biodiversity loss on ocean ecosystem services. Science, 314. 787-790.

WWF, 1998. Estimating overcapacity in the global fishing fleets. WWF, Washington, D.C.

Yamamoto, T., 1996. The fundamental difference in fisheries management between Japan and the western countries. Japan International Fishery Research Society (JIFRS).

Zalinge, N.V., Thuok, N., Tana, T.S., 1998. Where there is water, there is fish? Fisheries issues in the lower Mekong basin from a Cambodian perspective, International Association for the Study of Common Property, Vancouver, Canada.